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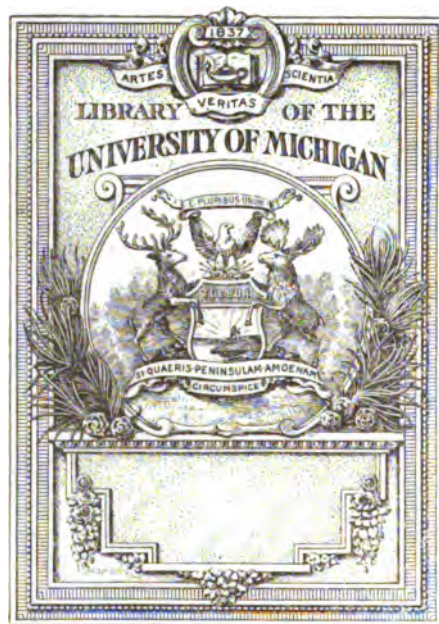
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SIXTH ANNUAL REPORT
OF THE
PENNSYLVANIA
DEPARTMENT OF AGRICULTURE.

PART I.



1900.

WM. STANLEY RAY,
STATE PRINTER OF PENNSYLVANIA.
1901,



PENNSYLVANIA DEPARTMENT OF AGRICULTURE.

OFFICIAL LIST.

JOHN HAMILTON, *Secretary,*
State College, Centre County.

A. L. MARTIN, *Dep'y Sec'y and Director of Farmers' Institutes,*
Enon Valley, Lawrence County.

LEVI WELLS, *Dairy and Food Commissioner,*
To May 16, 1900,
Spring Hill, Bradford County.

JESSE K. COPE,
From June 15, 1900,
West Chester, Chester County.

BENJ. F. MACCARTNEY, *Economic Zoologist,*
Hamilton, Jefferson County.

J. T. ROTHROCK, *Commissioner of Forestry,*
West Chester, Chester County.

LEONARD PEARSON, *State Veterinarian,*
Philadelphia.

M. D. LICHLITER, *Chief Clerk,*
Pittsburg.

GEORGE E. HUTCHISON, *Clerk, Dairy and Food Commissioner,*
Warriors' Mark, Huntingdon County.

FRANK S. CHAPIN, *Clerk, Economic Zoologist,*
Milton, Northumberland County.

ROBERT S. CONKLIN, *Clerk, Commissioner of Forestry,*
Columbia, Lancaster County.

LEWIS VANDERSLOOT, *Stenographer,*
York, York County.

GEORGE F. BARNES, *Messenger,*
Rossville, York County.



REPORT

OF THE

SECRETARY OF AGRICULTURE.

HARRISBURG, PA., *January 1, 1901.*

Hon. William A. Stone, Governor of Pennsylvania:

Sir: In compliance with the requirements of sections 2, 3 and 6 of the act of Legislature of March 13, 1895, establishing this Department, I have the honor to present herewith my report for the year 1900, being the sixth annual report of the Department of Agriculture of Pennsylvania.

The year 1900 has been one of prosperity for the farmers of Pennsylvania. The prices of all farm products have been above those of the previous year, and with the exception of hay, the yield has been up to the average of other years. The demand for articles produced by our mills and mines has stimulated mining and manufacture, thereby securing profitable and regular employment to a large number of laborers whose daily needs for food and clothing have furnished a remunerative home market for most of the farmers' crops.

The price of improved farm land in Pennsylvania has advanced, and there is no lack of tenants for farms that are at all favorably located and in good condition. Poor, run-down or badly located farms are not wanted, and in the same class are poor, run-down or ill-bred animals. The complaints of low prices and hard times among the farmers of the State come chiefly, either from political agitators whose occupation is to beget discontent, or from the occupants of ill conditioned farms, or the owners of ill-bred and unprofitable stock.

Agriculture in this State was never more advanced than it is now, and agricultural people in Pennsylvania never had better op-

portunities for lucrative returns for their labor, than have been before them during the past year. That the farmers of Pennsylvania have profited by their opportunities, is proven by the reports of the increase in the farmers' bank accounts which have been received from all sections of the State.

A circular letter was prepared in the autumn of 1900, addressed to about 125 bankers and distributed in all of the counties of Pennsylvania, asking for information as to the condition of the bank accounts of farmers since 1895, rating the deposits of that year at 100 per cent. One hundred and seventeen replies have been received. Twenty-nine were unable, for various reasons, to give data. Eighty-eight gave statements. The result shows that there has been a steady increase in the bank accounts of farmers in Pennsylvania since 1895. The average shows 104½ for 1896, 115½ for 1897, 124½ for 1898, and 144½ per cent. for 1899, or an increase of 44½ per cent. since 1895. Inquiry also shows that the debts of farmers in Pennsylvania are for the most part, balances due upon farm properties purchased by them, and not for losses occasioned in the conduct of their business. Farm mortgages are being rapidly lifted, and while this is being done, the farmer is enjoying a comfortable living for himself and family, and more children of farmers are being sent into the higher educational institutions than ever before in our history.

The statements, therefore, that appear from time to time, alleging that farming in Pennsylvania is retrograding and that this business is becoming more and more unprofitable as the years elapse, are unsupported by any reliable evidence. On the contrary, the facts show that the exact reverse is true. Farming in Pennsylvania is profitable, and is also rapidly becoming a highly scientific and most difficult profession, requiring the highest intelligence and most capable management to properly conduct. Because it is advancing beyond the capacity of men of less than average ability, therefore the cry of the incapable who are being left behind by the operations of the inexorable law of the "survival of the fittest," is heard. It is true that some men who once were able to pursue agriculture profitably can no longer do so, but their inability is due not to the unprofitable character of the occupation, but to their own failure to keep abreast of the advanced methods and scientific knowledge required by modern conditions in the agricultural profession. The old time farmer can no more succeed in the use of the old time methods and with the old time appliances than the engineer of forty years ago can succeed if he insists upon the use of the knowledge of that period. The crying need in agriculture to-day, is for more knowledge, and those who would succeed must

inform themselves, otherwise they will fail, and no lamentation, however loud or sincere, will prevent it. Those, therefore, who would benefit agriculture in this age must address themselves to the dissemination of accurate, reliable and applicable information among agricultural people. There is no other remedy for existing ills and no other salvation from those yet to be met.

This Department has undertaken to work along these lines. During the past year its operations have been wide, extended and most important, covering the whole list of subjects outlined in my report for 1899.

The extent of the operations of the Department can be partly understood from the following recital of the work which it embraces: The Farmers' Institutes; Crop Reports; The Inspection of Foods; Enforcement of the Pure Food Laws; Dairy and Food Statistics; The Purchase of Forest Lands; The Preservation and Control of our Forests; The Conservation of Water; The Improvement of Soils; The Control of Injurious Insects; Blight, Mildew, Infectious Disease among Trees; Market Gardening; Flower Gardening; Orchard Culture; The Inspection of Cattle Herds; The Prevention of Disease among Domestic Animals; The Control of Infectious and Contagious Diseases among Animals; The Analyses of Fertilizers; The Publication of Bulletins upon Important Farm Topics; Special Scientific Investigations into the Problems of Agriculture; The Publication of Reports; Dissemination of Information upon Good Roads; Agricultural Education in the Public Schools and Colleges; Legislation for the Benefit of Agriculture; The Aid and Encouragement of Agricultural Organizations; Country and Village Improvement Societies, and correspondence upon a wide range of questions which interest agricultural people. These and other subjects are a part of the work of the Department of Agriculture of this State. This work is distributed among several Divisions or Bureaus of the Department, and each Division, through its official head, is entrusted with carrying out of the details which the class that it embraces involves.

The following summary shows the classification and the particular Division to which each class of subjects is assigned.

SUMMARY.

DIVISION OF FARMERS' INSTITUTES. The work of this Division is educational, carrying information to the districts in which

the farmers' live, and reaching during the past year about one hundred and fifty thousand farming people.

CROP REPORTS. The system of crop reports is made part of the work of the Institute Division. Careful reporters are engaged in collecting data for the Department in every county in the State. These data are then arranged and published in the Annual Report.

THE DAIRY AND FOOD DIVISION. This Division is under the immediate supervision and direction of a Dairy and Food Commissioner, who is charged with the enforcement of the laws relating to the inspection of the character of the various foods on sale in the State, and the prosecution of those who are found violating the law. The Commissioner has charge also of the Dairy industry of the State, including dairy statistics and improved management of creameries and dairy herds.

DIVISION OF FORESTRY. The Commissioner of Forestry is charged with the development of the forestry interests of the State. As a member of the State Forestry Commission for the purchase of forest lands for the State, he is engaged in investigating forest lands offered for sale, and acts as the executive officer of this Board. He also recommends to the Board of Property, lands which he considers suitable for State reservations, and with their approval completes the purchase and turns over the lands to the Department of Agriculture, of which his Division forms a part.

He is also charged with the work of investigating the soils of the State, with a view to their reclamation and improvement, and is also required to report upon the timber cut during the year and the amount destroyed by forest fires.

DIVISION OF ECONOMIC ZOOLOGY. This Division is in charge of a Commissioner who is known as The Economic Zoologist, whose duties are to make examination and investigations into the insect enemies of crops and report upon their ravages and give suggestions for their control or eradication. There is assigned to this Division the Orchard, Greenhouse, Market Garden and Flower Gardening industries of the State. Information is sent out by him to those engaged in these industries, giving the latest scientific and practical discoveries in these lines of work, and as new questions arise he endeavors to have investigations made and proper solution discovered to meet the new conditions.

DIVISION OF VETERINARY SCIENCE. The chief of this Division is by law, required to be "a graduate of some reputable veterinary college." The law further makes it the duty of the Secretary of Agriculture "to obtain and distribute information on all matters relating to the raising and care of stock and poultry; the best methods of producing wool and preparing the same for market."

This work is consigned to the Veterinary Division. The Veterinarian is also a member of the State Live Stock Sanitary Board, whose duty it is to "protect the health of the domestic animals of the State," and powers to adopt means to effect this are granted by the act creating the Board.

FERTILIZER INSPECTION AND ANALYSES. The work of the licensing and inspection of Commercial Fertilizers is in the hands of the Secretary. Agents are employed to collect samples of goods upon the market, and these are transmitted to the chemist for analyses. The results are published for the information of farmers and dealers, twice each year.

SPECIAL INVESTIGATIONS. The law creating the Department provides for "the employment of experts to make special examinations and investigations." These experts are selected by the Secretary, and the results of their examinations are printed either in a special Bulletin or in the Annual Report. The investigations are upon subjects relating to the agricultural industry.

BULLETINS. The Secretary is also directed to "publish from time to time such bulletins of information as he may deem useful and advisable," "the number not to exceed five thousand copies of any one bulletin." Seventy such publications have been issued since 1895.

ANNUAL REPORT. Each year the Secretary is directed to "make an Annual Report to the Governor," and in this report "he may include so much of the reports of other organizations as he shall deem proper." Thirty-one thousand six hundred copies are authorized to be distributed; 9,000 to the Senate, 20,000 to the House of Representatives, 2,000 copies to the Secretary of Agriculture, 500 copies to the State Librarian, and to the State Experiment Station, 100 copies.

BOOKS OF ACCOUNT. The General Books of Account of the Department are in charge of the Secretary, and the Special Books are in charge of the several Division officers.

REPORTS OF DIVISION OFFICERS. Monthly reports of the operation of each Division for the preceding month are made to the Secretary by the chief of each Division, and special reports from time to time are made as may be necessary in order to keep the Secretary fully informed as to the work of the several Divisions. At the close of the year, full reports of the work of each Division are made out and transmitted to the Secretary, and printed in the Annual Report of the Department. The care of the library, the reading of proof and the mailing lists are in charge of the Chief Clerk.

FARMERS' INSTITUTES.

The education of the farmers of the State, by means of the "Institute School," has been more successful than in any previous year. Three hundred and twenty-two days were devoted to this method of giving instruction in agriculture. The average daily attendance, is reported by the Director of Institutes, as being four hundred and sixty-five, and the total number of people reached was 149,855.

The Director reports that "Institutes were held in all the counties of the State. In twelve counties the attendance reached over 3,000 to the county. The banner county was Montgomery, with a total attendance of 6,100. The county having the second highest attendance was Perry; her attendance, including the summer institute, was 5,505. In fourteen counties there were in each over 3,000; in twenty-one counties the attendance was between two and three thousand." The State was divided into five sections, and days allotted to each county and section. The apportionment was made on the basis of two days of institute, to every county having not over 1,000 farms; three days, to each county having more than 1,000 and not over 1,500; afterwards, one day, for each 1,500 farms or fraction thereof additional. The following schedule shows the number of days allotted to each county, on this basis:

Apportionment for 1899-1900.

Section 1.		Section 2.		Section 3.		Section 4.		Section 5.	
COUNTY.	Days.	COUNTY.	Days.	COUNTY.	Days.	COUNTY.	Days.	COUNTY.	Days.
Adams,	5	Blair,	4	Allegheny,	6	Bradford,	3	Bucks,	7
Bedford,	5	Columbia,	5	Armstrong,	5	Clinton,	3	Berks,	7
Chester,	7	Centre,	4	Butler,	6	Clarion,	6	Carbon,	3
Cumberland,	4	Clearfield,	4	Beaver,	4	Cameron,	3	Delaware,	4
Fayette,	5	Cambria,	4	Crawford,	3	Elk,	3	Lehigh,	5
Franklin,	5	Dauphin,	4	Erie,	6	Forest,	3	Luzerne,	4
Fulton,	3	Huntingdon,	4	Greene,	4	Jefferson,	4	Lackawanna,	4
Junata,	4	Indiana,	6	Lawrence,	4	Lycoming,	5	Montgomery,	6
Lancaster,	9	Lebanon,	4	Mercer,	6	McKean,	4	Monroe,	4
Perry,	4	Mifflin,	3	Venango,	4	Potter,	4	Northampton,	5
Somerset,	5	Montour,	2	Washington,	5	Sullivan,	3	Philadelphia,	3
York,	3	Northumberland,	4	Westmoreland,	5	Tioga,	6	Pike,	2
.....	.....	Schuylkill,	4	.....	.....	Warren,	4	Susquehanna,	6
.....	.....	Snyder,	4	.....	.....	Wyoming,	4	Wayne,	6
.....	.....	Union,	3	.....	.....	.....	.....	.....	.....
64		59		63		59		65	

The cost of these Institutes was an average of about \$37.00 per day, and at all of these meetings, the Department furnished at least three lecturers.

The limit of number of Institutes has been reached until the appropriation, which is now \$12,500 per year, is increased; and the limit as to the number who can attend has likewise been reached, for the capacity of the halls has been taxed to their utmost, and the size of these rooms controls the number who can be present. The development of interest on the part of the farmers of the State in this course of instruction has been very remarkable, and now the difficulty is to select the places where Institutes shall be held, from the large number and urgency of the applications.

The greatest cordiality and most generous spirit of co-operation exists on the part of the local boards toward the Department. This greatly simplifies the work of the Director in arranging for the Institutes, and in the selection of lecturers who are to represent the State. The demand in every county is for "more Institutes;" but this cannot be met, except as the means of holding them are increased.

New Methods.

In my opinion, the time has now arrived, when Pennsylvania should take a step in advance, in this Institute work. Hitherto we have been devoting our efforts to the holding of meetings of farmers for the discussion of the leading problems in agriculture, and the results attained by this method, have abundantly justified and proven its wisdom. They were chiefly "revival" meetings, to awaken an interest in the scientific side of agriculture and start farming people to thinking along new lines and encourage the reading of the excellent literature, which is now issued by the State and United States Departments of Agriculture, the results of the investigations at the Experiment Stations, and the practical thoughts suggested by an advanced agricultural press.

A large portion of our agricultural people are now awake to their interests, as is evidenced from the volume of correspondence which the Department has to answer, and the large number of those who are engaged in study in the Correspondence Courses, conducted by the Agricultural School of the State College, as well as the numerous meetings by Farmers' Clubs, Granges, Alliances, Agricultural Societies and kindred organizations of farmers. The teaching, thus far, has of necessity, been by oral explanation and description of the processes of nature in her various operations; in other words, we have been dealing with practical things at arm's length. We find now that we need to get down closer to the actual work upon the farm, to see precisely the conditions under which each man is placed, and then, after a full knowledge

of all of his surroundings and conditions, advise him as to improvements that he can adopt, which will add to his comfort and increase his income. This means personal visitation, to the workers on the farms, to the creameries and cheese factories, the dairies and herds, the orchards and vineyards, the gardens and greenhouses, carrying information to these workers which will aid them in their occupation, and when necessary, by practical demonstration, show exactly how the suggestions can be carried into effect.

A skillful operator with a spray pump in an orchard, can give more practical illustration in thirty minutes, than by a whole day's talk upon fungicides or spraying methods. A skilled veterinarian in a herd of cattle, a flock of sheep, or a stable of horses, can show the owner in a few minutes, more that will be of value to him than can possibly be done by the most extensive correspondence. The same is true in all lines of agriculture; and we should now begin this new and most effective method of teaching agriculture, by object lessons on the ground. This will mean the permanent employment of a few competent, skilled teachers, who shall visit certain districts in turn, organize small clubs of farmers, and go out on their premises and show how the most approved methods known may be taken advantage of by the ordinary farmer on an ordinary farm. The practical difficulties that every farmer has to meet will there be seen, and these skilled experts can there study the problems under the most favorable conditions, and endeavor to discover their solution. It is in this way that all of the marked advances of science in the past, in its application to art, have come, and it is in this way that future development in these directions must be effected. A farmer here and there through the country could be induced to plant an acre of wheat or corn or rye or grass in some way prescribed by the expert who represents the Department of Agriculture of the State. Plant this acre in some conspicuous place, along some much frequented highway, and if the acre so treated shows a marked improvement over the others treated in the ordinary way, there will here be an object lesson to every passerby, which will excite inquiry and result in its adoption by many who have witnessed the demonstration.

In this way could be taught the judicious use of fertilizers, the most satisfactory rotation of crops, the value of cultivation for the conservation of moisture in the soil, the effect of fungicides upon fruits and vegetables, the value of new crops never before tried in this country, the economy of machinery, and a thousand other lessons that agricultural people need to learn.

To attempt this work, in addition to carrying on the Institutes as now organized, will require at least \$25,000 per year, and no money appropriated by the State would bring in a larger return.

CROP REPORTS.

The Division of Institutes has also charge of the collecting, each year, of statistics showing the prices of farm crops, the rates of wages of farm laborers, the value of agricultural lands, the value of farm animals, together with other items of interest and value to the citizens of the State. These results are all published in the Annual Report. The reports submitted, show that the prices of farm produce of every kind have advanced—wheat from 68 cents in 1899, to 73 cents in 1900; corn from 42 cents to 48 cents; oats from 26 cents to 32 cents; potatoes from 42 cents to 53 cents; clover hay from \$8.20 per ton to \$11.20; timothy hay from \$10.69 to \$13.85; butter from 20 cents to 22 cents; horses from \$78.49 to \$87.61; cows are the same as in 1899; the same is true of ewes and lambs. Farm labor has increased a little less than one dollar per month. Well improved farm land is worth, on the average, \$60.00 per acre, and average farm land is reported at \$38.00 per acre.

COUNTY AND LOCAL AGRICULTURAL SOCIETIES.

The Deputy Secretary has also charge of the work of getting statistics from the county and local agricultural societies of the State. He gives the number reported to the Department last year, as 91. Sixty of these societies held fairs during the fall of 1900. It is the purpose of the Department to endeavor to come into closer relations with these fair associations, with the view of aiding them in their work and encouraging them to extend their operations and influence through a wider circle than they have hitherto. These societies are made up of our most capable and progressive citizens, and their services in advancing the cause of agriculture would be invaluable if they could be secured. Plans are being matured for securing their co-operation in advancing the agricultural interests of the several counties in which they are located, by giving new direction, to some of the energy and skill, that is now wholly devoted to a single line of work.

THE DAIRY AND FOOD DIVISION.

The work of this Division during the year has been under difficulties, which only those who have had them to meet, can appreciate. These difficulties, were chiefly those connected with the new law, known as the oleomargarine law of 1899.

Inasmuch as the Dairy and Food Division, and the entire administration of the Department of Agriculture have been severely criticised in their administration of this law, it is proper, now, when the facts can be dispassionately considered, that a clear and impartial statement of the circumstances surrounding the case, be made.

History of Oleomargarine Legislation.

For the better understanding of the situation, it will be well to first, briefly, give the history of oleomargarine legislation in this State.

On the 21st of May, 1885, an act was approved prohibiting the sale of oleomargarine in Pennsylvania, under a penalty of \$100 and costs, to be recovered by any person suing in the name of the Commonwealth; one-half of the fine to go to the county and the other half to the prosecutor.

It was provided that the violators of the law could also be prosecuted criminally; and upon conviction "shall be punished by a fine of not less than \$100, nor more than \$300, or by imprisonment in the county jail for not less than ten nor more than thirty days, or both, such fine and imprisonment for the first offense, and imprisonment for one year for every subsequent offense." It was made the duty of constables to make quarterly reports to the court of quarter sessions of violators of the law.

By an act approved May 26, 1893, the law of 1885 was modified, and the duty of enforcing it was placed in the hands of the State Board of Agriculture, and the president of that Board was authorized to appoint an agent, to be known by the name and title of Dairy and Food Commissioner, who was specifically charged with the enforcement of "all laws now enacted, or hereafter to be enacted in relation to the adulteration or imitation of dairy products." Under this law the Dairy and Food Commissioner received a salary of \$2,000 and his necessary expenses. He had power "subject to the approval of the State Board of Agriculture, to appoint and fix the compensation of such assistants, agents, experts, chemists, detectives and coun-

sel as may be deemed by him necessary for the proper discharge of the duties of his office." The one-half of the fines, instead of going to private informers, as was the case under the act of 1885, are by this act paid to the Dairy and Food Commissioner, and are to be used for the payment of agents, chemists, attorneys, etc., employed by him.

By the act approved March 13, 1895, establishing the Department Agriculture, the Dairy and Food Commissioner is made an official of that Department, and is appointed by the Governor. His duties are "under the direction of the Secretary of Agriculture such as are prescribed by the act of May 26, 1893."

By act of May 5, 1899, the sale of oleomargarine or butterine is permitted in Pennsylvania, provided it be "free from coloration or ingredients that cause it to look like butter," and that those who manufacture or sell "shall first obtain a license and pay a license fee," and "shall stamp each package with the words OLEOMARGARINE or BUTTERINE," and shall exhibit a "sign or signs, clearly setting forth that he, she or they are engaged in the manufacture or sale of oleomargarine or butterine, or any similar substance, as the case may be, which said sign or signs * * * shall be hung up in a conspicuous place or places on the walls of the rooms or store in which the oleomargarine or butterine or other similar substance is manufactured or sold."

Under this law, the enforcement is placed exclusively in the hands of the Dairy and Food Commissioner, and all fines, with costs, are to be paid to him, or his agents, and by him to be paid into the State Treasury, to be drawn upon for the purpose of enforcing this law, upon presentation of warrants signed by the Secretary of Agriculture, and approved by the Auditor General.

The license law, as has been stated, went into effect May 5, 1899, and repealed the laws of 1885 and 1893. Under the new law the Dairy and Food Commissioner, solely, is charged with its execution.

It was necessary, before the law could be put into effect, that dealers throughout the State should have an opportunity to know what the provisions of the law were. Ten thousand copies were printed and distributed by the Dairy and Food Division. License blanks and books of record and account were prepared and printed. It took about one full month to get the laws into the hands of the dealers. It was, of course, impossible for the dealer to comply with the law before he had the proper blanks upon which to make out his application for license, and the Department had license blanks in hand ready to issue. It was, therefore, about the 1st of June before applications for licenses were received, and in that

month the Department issued one hundred and fifty licenses under the new law.

The agents of the Department were then instructed to collect samples and submit them to the chemists for analyses. By the time these were taken and the chemists had opportunity to analyze and report upon them and suits be begun before the magistrates, the courts had adjourned for their summer vacation.

Color Clause.

On the first of August, 1899, a sample of colored oleomargarine was taken from J. K. Van Dyke, of Philadelphia, who represented the Oakdale Manufacturing Company, of Providence, R. I. Prosecution was begun before Magistrate Eisenbrown. The defendant was fined \$100 and costs. An appeal was taken from this decision to the court of common pleas No. 4, of Philadelphia county, as of September term, 1899, No. 226. On the 20th day of November the Commonwealth filed a statement to which a demurrer was filed by the defendant. Argument thereon was had and demurrer overruled in an opinion by Judge Arnold, handed down January 17, 1900. From this opinion an appeal was taken by the defendant to the Superior Court of Pennsylvania on the 15th day of February, 1900. The case was advanced on the list and argument was had thereon on the 20th day of March, 1900, and the decision of the lower court was affirmed by the Superior Court in an opinion filed April 30, 1900.

May 15, 1900, writ of certiorari from the Supreme Court. The same day the record was sent to the Superior Court.

May 29, 1900. Motion to quash filed, and petition to have motion to quash granted at once, filed on motion of attorneys for the appelle.

July 7, 1900. Answer of appellant to petition of appelle for motion to quash appeal filed, by attorney for appellant.

July 11, 1900. Appeal quashed per curiam.

This was a case to test the constitutionality of the color clause in its relation to the Interstate Commerce law.

Another case was brought in the city of Pittsburg, raising the same question, with regard to the legality of the color clause as it affected sales of oleomargarine in the retail trade in Pennsylvania. Pending the decision of these cases it was the opinion of attorneys that it would be unsafe to bring any considerable number of prosecutions against dealers for violation of the color clause, but suits were brought against dealers upon all of the other provisions of the law.

Enforcement of the Law.

The day after the decision was rendered the following letter

was issued by the Secretary of Agriculture, directed to Major Wells, Dairy and Food Commissioner, and a copy of the same sent to every agent of the Department:

Harrisburg, Pa., May 1, 1900.

Hon. Levi Wells, Dairy and Food Commissioner, Harrisburg, Pa.:

My Dear Sir: I am just informed that the Superior Court has affirmed the decision of the court below in the Van Dyke case declaring the color clause of the law relating to the manufacture and sale of oleomargarine in this State constitutional.

I desire you to send out at once to every agent the following directions:

"To Agent of the Dairy and Food Department:

"Dear Sir: The Superior Court has handed down an opinion declaring the color clause of the law of 1899, relating to the manufacture and sale of oleomargarine constitutional.

"You are hereby directed to enforce this law in all of its provisions, requiring that licenses shall be taken out by all dealers in oleomargarine or butterine, that placards containing the words 'oleomargarine' or 'butterine' shall be posted in conspicuous places; that all tubs, packages or parcels containing oleomargarine or butterine shall be marked in a conspicuous place with a placard containing the words 'oleomargarine' or 'butterine' in plain, uncondensed gothic letters, not less than one inch long, and such placards shall not contain any other words thereon; and every print or roll shall be wrapped in wrappers plainly stamped on the outside thereof with the words 'oleomargarine' or 'butterine,' and where oleomargarine or butterine or other similar product is sold from solid packages, before being delivered to the purchasers it shall be wrapped by the seller thereof in a wrapper plainly stamped on the outside thereof 'oleomargarine' or 'butterine,' and said wrapper shall contain no other words.

"All oleomargarine or butterine shall be sold free from coloration or ingredients that cause it to look like butter.

"You will visit all stores where oleomargarine is sold, as frequently as possible, take samples or suspected goods, and where the law has been found to be violated in any particular, suit shall be brought against the dealer, and the penalty provided by law exacted.

"Agents are positively forbidden to compromise any case, but will see that it is prosecuted to the full extent of the law.

"You are directed to make full weekly reports to the Dairy and Food Commissioner, giving full information in regard to samples taken, places visited, suits brought and cases concluded, keeping

him thoroughly informed with regard to all of the details of the work in your territory.

Very respectfully,

"JOHN HAMILTON,
"Secretary of Agriculture."

Up to this date, as has been stated, the law, so far as the color clause was concerned, could not be enforced, and the Department was guided in its action by the opinion of some of the best attorneys in the State, in withholding suits and prosecutions against violations of the color clause, until the decision of the court was had. Samples, however, were taken in the meantime, and cases were ready to be brought as soon as the decision of the Superior Court would be reached.

Ever since the decision of the Superior Court was handed down, a most vigorous and determined effort has been made to discover offenders and to bring them to account for violation of the law. Indisputable evidence of this is furnished by the following statement of the work done during the year, from January 1, 1900, to December 6, 1900, as taken from the books of the Dairy and Food Commissioner:

Number of licenses issued during the year,	467
Number of samples taken by the agents and analyzed during the year,	1,919
Number of samples found pure or true to name,	806
Number of prosecutions brought under oleomargarine law,	945
Number of prosecutions brought under pure food law,	76
Number of prosecutions brought under renovated butter law,	60
Number of prosecutions brought under cheese law, ..	7
Number of prosecutions brought under vinegar law, ..	7
Number of milk cases,	19
Number of cases brought to a final termination through the courts,	126

Samples Taken Since January 1, 1900.*

Allspice, pure,	7
Butter, pure,	638
Butter, renovated,	60
Butter, oleomargarine,	945
Butter, color,	4
Baking powder, pure,	1

*For statement showing the work of the entire year to Dec. 31, 1900, see Report of the Dairy and Food Commissioner page 62.

Buckwheat flour, pure,	1
Buckwheat flour, adulterated,	1
Cream of tartar, pure,	4
Cream of tartar, adulterated,	1
Cinnamon, pure,	4
Catsup, pure,	2
Catsup, adulterated,	2
Cream, pure,	1
Cocoa, pure,	4
Cocoa, adulterated,	1
Chocolate, adulterated,	2
Coffee, pure,	1
Cheese, up to standard,	5
Cheese, below standard,	1
Cloves, pure,	3
Cloves, adulterated,	1
Extract of vanilla, pure,	1
Extract of vanilla, adulterated,	14
Fruit syrup, adulterated,	2
Flour, adulterated,	3
Ginger, pure,	3
Ginger, adulterated,	2
Grape juice, pure,	1
Honey, pure,	3
Lard, pure,	6
Lard, comp.,	2
Lemon extract, pure,	4
Lemon extract, adulterated,	14
Maple syrup, pure,	1
Maple syrup, adulterated,	1
Milk preservative,	2
Milk, pure,	75
Milk, preservaline found,	8
Milk, added water,	11
Mustard, pure,	5
Mustard, adulterated,	2
Pepper, pure,	10
Pepper, adulterated,	19
Peas, canned, adulterated,	2
Raspberry jam, adulterated,	1
Soda, pure,	1
Vinegar, pure,	30
Vinegar, adulterated,	7

Total, 1,919

TOTAL NUMBER OF CASES BROUGHT BY THE DAIRY AND FOOD DIVISION OF THE DEPARTMENT OF AGRICULTURE FROM JANUARY 1, 1900, TO DECEMBER 6, 1900, SEPARATED BY COUNTIES.*

County.	Total.	Terminated.	Pending.
Allegheny,	721	42	679
Beaver,	3	..	3
Bedford,	4	..	4
Berks,	6	1	5
Blair,	22	8	14
Cambria,	25	13	12
Carbon,	2	1	1
Chester,	4	3	1
Clearfield,	15	4	11
Columbia,	2	2	..
Crawford,	1	1	..
Dauphin,	9	2	7
Delaware,	18	8	10
Erie,	5	1	4
Fayette,	41	..	41
Indiana,	1	..	1
Jefferson,	1	..	1
Lawrence,	7	1	6
Lebanon,	14	13	1
Lehigh,	2	2	..
Luzerne,	6	1	5
Mercer,	2	1	1
Montgomery,	11	6	5
Northampton,	4	4	..
Northumberland,	1	1	..
Philadelphia,	117	2	115
Potter,	2	2	..
Somerset,	2	1	1
Schuylkill,	13	4	8
Tioga,	4	2	2
Venango,	1	..	1
Westmoreland,	47	..	47
Washington,	1	..	1
Total,	1,113	126	987

*For statement of cases brought for the entire year from January 1, 1900, to Dec. 31, 1900, see Report of the Dairy and Food Commissioner page 75.

Of the 1,113 cases brought during the year, 1,013 were prosecuted after April 30, 1900, the date of the decision of the Superior Court. The 100 cases brought from January 1, 1900, to April 30th, are classified as follows:

Oleomargarine cases,	81
Renovated butter,	1
Pure food,	13
Vinegar,	5
	<hr/>
Total,	100
	<hr/>

The foregoing schedule of work actually accomplished by the Department, is the only refutation needed to show the falsity of the charges that nothing, or next to nothing, had been done to enforce the law.

It will be noticed that a large number of suits are still pending—987. An examination shows that 794 of these are in the two courts of Philadelphia and Allegheny.

Limit of Powers of Dairy and Food Commissioner.

The power of the Dairy and Food Commissioner to prosecute offenders, consists in the securing of samples of suspected goods, having them analyzed, and when the goods are found to be adulterated in violation of the law, he has the party arrested, brought before a magistrate, tried on the evidence secured, and if found guilty, the defendant is bound over under bail to appear in court. The case has now gone as far as the Dairy and Food Commissioner can urge it. When it reaches the court it is in the hands of the district attorney. The Commissioner, or his attorneys, have no more power over the case at this stage of proceeding than any other citizen. All that they can do is to wait the pleasure of the district attorney and the court. If these officers decline to bring the cases before the grand jury and list them for trial, the prosecution has no remedy. They are effectually blocked as to any further progress. All of the cases that are now pending are in exactly this situation. They have been urged as far as the Commissioner and his attorneys can prosecute them, and now it is simply a question of when the courts will take them up.

The responsibility, therefore, is entirely with the courts and not upon the Dairy and Food Commissioner, or his attorneys, and all criticism that holds him responsible is unjust.

In the meantime, there is no law by which the offender can be restrained from continuing his illegal traffic. All that can be done

is to take additional samples, have them analyzed; if adulterated, arrest him and bring him before a magistrate, and if convicted, hold him in bail for court, where control ceases, and the Commissioner is again at the end of his power.

This can be repeated over and over and over again, and the result is practically the same. The cases that are pending in the Philadelphia and Allegheny county courts are all in precisely the same condition. It can be confidently stated that if the courts in these cities and elsewhere, will hear the cases of the Department promptly and impose the penalties authorized by the law, the illegal traffic in oleomargarine can be broken up inside of six months; but if they delay the hearings, or fail to impose the penalties, it will be impossible to destroy the traffic. All that can be done will be to multiply cases and await the action of the court.

The Department has determined that it will arrest every offender against the law and have him bound over to court, and thus divest itself of all responsibility for any failure of the law that may result. The officers of the Department having performed their duty, are not responsible for the acts of district attorneys, grand juries or courts.

The New York Law.

If the provisions of the New York law, which provides for the issuing of an injunction, restraining a dealer who has been arrested for violating the law, from continuing to sell the kind of adulterated goods for which he was arrested, until the determination of the suit were incorporated into the Pennsylvania law, then we could afford to wait, for during this period the dealer could not sell without placing himself in contempt of court, and be liable to fine and imprisonment at the discretion of the court, without the formality and delay of a trial.

Such an amendment to our law would greatly aid in its enforcement.

The law should also be amended in another respect. At present, under the oleomargarine law we have no power to enter the premises and make search for suspected goods and take samples for analysis; but all of our samples must be obtained by detectives who are unknown and unsuspected, thus making it very difficult for the Department to secure samples after the detective becomes known.

Here again the New York law is an improvement upon ours, for it authorizes the agents of the Department to enter, make search and take samples openly and without interference. For information, copies of these sections are herewith appended.

Extracts from the New York Law.

POWERS OF THE COMMISSIONER, HIS ASSISTANTS AND EMPLOYES. "The Commissioner of Agriculture, his clerks, assistants, experts, chemists, agents and counsel employed by him, shall have full access to all places of business, factories, farms, buildings, carriages, cars and vessels used in the manufacture, sale or transportation within the state of any dairy products or any imitation thereof, or of any article or product with respect to which any authority is conferred by this chapter on such Commissioner. They may examine and open any package, can or vessel containing or believed to contain any article or product, which may be manufactured, sold or exposed for sale in violation of the provisions of this chapter, and may inspect the contents therein and take therefrom samples for analysis."

Section 10. WHEN INJUNCTIONS MAY BE OBTAINED. "In an action in the Supreme Court for the recovery of a penalty or forfeiture incurred for the violation of any of the provisions of this chapter, an application may be made on the part of the people to the court or any justice thereof for an injunction to restrain the defendant, his agents and employes from the further violation of such provisions. The court or justice to whom such application may be made, shall grant such injunction on proof, by affidavit, that the defendant has been guilty of the violations alleged in the complaint, or of a violation of any such provision subsequent to the commencement of the action, and in the same manner as injunctions are usually granted under the rules and practice of the court. No security on the part of the plaintiff shall be required, and costs of the application may be granted or refused at the discretion of the court or justice. If the plaintiff shall recover judgment in the action for any penalty or forfeiture demanded in the complaint, the judgment shall contain a permanent injunction, restraining the defendant, his agents and employes, from any further violation of such provision of this chapter. Any injunction, order or judgment obtained under this section, may be served on the defendant by posting the same upon the outer door of the defendant's usual place of business, or where such violation was or may be committed, or in the manner required by the code of civil procedure, and the rules and practice of the court. Personal service of the injunction shall not be necessary when such service cannot be secured with reasonable diligence, but the service herein provided shall be deemed sufficient in any proceeding for the violation of such injunction."

Grout Bill.

The passage of the Grout bill by Congress of the United States, whereby a ten cent tax is imposed upon all colored oleomargarine manufactured, and the operations of the Inter-State Commerce Law are suspended as to the oleomargarine trade, will greatly aid the State Dairy and Food authorities in suppressing the oleo traffic. This bill has passed in the House by a large majority, but it is not yet out of danger.

The McCann Case.

An appeal has been taken to the Supreme Court by McCann & Co., of Allegheny county, contesting the constitutionality of the color clause of the oleomargarine law. The history of this case is as follows:

July 27, 1899. Information charging Owen McCann, trading as McCann & Co., with selling colored oleomargarine.

August 26, 1899. Hearing before magistrate, and defendant fined \$100 and costs.

September 18, 1899. Court of common pleas No. 3, Allegheny county, issues a writ of certiorari directing alderman to return record to court.

October 10, 1899. Alderman returns record to court.

October 27, 1899. Specifications of error filed in court by defendant.

December 12, 1899. Case argued before full bench in court of common pleas No. 3.

December 12, 1899. Decision rendered, dismissing exceptions and sustaining the Commonwealth.

December 19, 1899. Appeal to Superior Court.

April 26, 1900. Argument before Superior Court.

July 26, 1900. Judgment affirmed, sustaining the Commonwealth, with opinion by Rice, P. J.

August 18, 1900. Petition for appeal to Supreme Court filed.

September 18, 1900. Petition for appeal forwarded to Mestrezat, J.

October 12, 1900. Petition allowed by Supreme Court.

October 19, 1900. On petition of counsel for Dairy and Food Department, case is advanced on the list, and set for argument at Philadelphia, January, 1901.

In the meantime the judges of Allegheny county have decided that the oleo cases now before that court shall be held until the Supreme Court has decided the McCann case now before it.

Two judges in other counties have taken a similar stand, and all of our cases in their courts are likewise awaiting this decision.

Appropriation Needed.

If the law is finally decided to be constitutional, a large appropriation will be needed to enforce it. The appropriation last year was \$12,500. This was supplemented by license fees amounting to \$46,977.00. These licenses were taken out at the time when the color clause was being contested in the courts, and in all probability, in the expectation on the part of the dealer that the law would be declared unconstitutional. If, therefore, the law is now sustained by the Supreme Court, the sale of colored oleomargarine in Pennsylvania will be illegal and no one will take out a license for the privilege of dealing in the uncolored goods, owing to their unsalable character. The money, therefore, necessary to enforce the law will have to be provided from some other source, and the Legislature will need to appropriate the necessary amount from the general funds of the State. In New York, an annual appropriation of \$100,000.00 is made for the purpose of enforcing the oleomargarine law.

Oleomargarine a Menace.

The admitting of oleomargarine in competition with the dairy products of the State, endangers a great industry that is now a part of our system of agriculture, more widely distributed than any other. We have now about 1,100,000 cows in Pennsylvania. Their product is about 90,000,000 to 100,000,000 pounds of butter per year; and according to the census of 1890, the milk product was 437,525,349 gallons. These cows are distributed among 211,412 farmers' families, consisting of over 1,000,000 persons, or about one-fifth of our entire population. The income of the farming people of Pennsylvania last year, from butter alone, amounted between eighteen and twenty millions of dollars; and the milk product, at eight cents per gallon, amounted to \$35,000,000 more. This vast sum is a new product each year, adding this much to the actual wealth of the State, and is distributed all through the Commonwealth, going to the support of over one million of people, enabling them to maintain themselves in comparative comfort. The loss of such a sum as this by the agricultural people of the State would be a calamity, particularly, because, much of the material that is used in the feeding of these dairy cows, would, if the industry were destroyed, be left on the farmers' hands valueless.

If the product of these animals were seriously threatened, there would, also, be an immediate depreciation in the value of milk cows throughout the Commonwealth, amounting to many millions of dollars, and would involve the partial or total loss of the stabling, cream-

ery buildings and machinery, that are now in use in the prosecution of this industry. A large number of our people, also, would be thrown out of employment. Instead of men, women and children on the farms, having at all seasons, occupations suited to their strength and attainments, there would be, in the cutting off of this line of work, comparative idleness during a considerable portion of the year.

The people of this State require about 200,000,000 pounds of butter annually to supply their needs. The business, therefore, is one that has room for growth, and the doubling of the products of milk and butter, will double the income of the farming people—an increase of from fifty to sixty millions of dollars annually.

If oleomargarine were wholly substituted for butter in this State, it would mean a direct loss, on that article alone, of from thirty to forty millions of dollars per year, and the profits of the new industry, instead of being distributed among a million of people, would be retained in the hands of a very few, rendering them inordinately rich at the expense of those whose industry they had destroyed.

It is true, that, in no event, can oleomargarine entirely supplant butter production, but enough is known to make sure, that this product, which can be made for about 7 cents per pound, will seriously injure the butter industry and effectually prevent its development. It would be extremely bad business policy, to drive out a source of revenue and means of livelihood, as important as the dairy industry, for the sake of benefiting a few individuals belonging to the oleomargarine trade; to take from one million of agricultural people the profits of their chief industry, and give these profits to a select syndicate of capitalists, that they may become enormously rich.

If this new industry required for its prosecution, the employment of two millions of people instead of the one million at present needed by the dairies, one could see how it might be to the advantage of the State to substitute the new industry for the old, because of the increased number of laborers that it would employ. But when it proposes to do away with a million of laborers and substitute therefor a factory system employing only a few workmen, the danger that will ensue becomes apparent to every thoughtful citizen. We need employment for more labor, instead of turning men idle who are now employed. We need additional markets for the rough products of our farms, instead of closing up the ones we now have. Under modern conditions, it is necessary to change farm articles of bulk into a more valuable and compact shape, in order to ship them to distant markets. The butter industry does this, and has

the additional advantage, over every other product, in that it at the same time removes almost no fertility from the farm.

The sale of oleomargarine as butter and in imitation of butter is a fraud, and it is also a menace to a great industry which comprises a large portion of our agricultural wealth.

Pure Food Laws.

The Dairy and Food Commissioner has also in charge, the enforcing of the Pure Food Laws of the Commonwealth. These relate to vinegar, milk, cheese and the other articles of food and drink which are found upon the markets of the State. The work is one of great magnitude and importance, and deserves the liberal support of the Legislature to enable the Commissioner to properly carry out the provisions of these several acts for the protection of the public health.

DIVISION OF ECONOMIC ZOOLOGY.

The Economic Zoologist reports a large increase in his correspondence during the year. Many inquire in regard to the best methods for combating the attacks of the numerous injurious insects that prey upon their crops, and also for remedies for the fungous and infectious diseases which affect vegetation to its serious injury. Bulletins of information upon special diseases and insect enemies of plants have been sent out to inquirers, and whenever necessary, as new pests appear, expert assistance has been secured, to investigate and give advice as to their control or eradication.

The San Jose Scale is spreading in the eastern portion of the State, and unless remedial legislation is soon had, the nurseries and orchards of the entire State will be infected. Present legislation is altogether inadequate, there being no law except that which was passed in the session of the Legislature of 1899, which is only operative when the local authorities take the initiative and inspect in their own district. These inspectors have no authority outside of their own township, and can do nothing to protect their neighborhood from infection from adjoining nurseries or orchards. We

have no law requiring the inspection of nurseries, or which will prevent the importation of diseased or contaminated stock from other States.

The effect is to make Pennsylvania the dumping ground for diseased and infected nursery stock, which cannot be sold elsewhere, because of the laws in nearby States, which require a certificate of inspection to accompany every consignment.

It is important that our fruit-growers be protected by the passage of a law requiring the inspection of all nursery stock which is raised in this State or is imported from another, and if found to be infected, which will compel the owner to destroy or disinfect it, so as to kill all insects or disease germs that may be present.

Hessian Fly.

A large area has again been visited by the Hessian Fly. Many wheat fields were completely destroyed last year by this pest, occasioning a loss of many thousands of dollars to the farmers of the State. It is well known that the period of activity of the "fly" is comparatively brief, as regards both the spring and fall broods. The times of their activity is not the same in all of the districts of the State, but varies with the latitude and altitude. The only method, as yet found practical, for protecting crops from its attacks, is to delay the seeding until the period of activity of the fly has passed. No general rule can be given, fixing this period, which will apply to the entire State, since the date varies as has been stated, according to the latitude and elevation. It would, however, be entirely practicable for a map of the State to be prepared, which would show the dates at which the fly appears in each locality and by marking the outlines of these districts and giving the dates appropriate for each; the farmers could know the time in which it would be safe to sow their grain. I recommend, therefore, that a sufficient appropriation be made for the use of the Department, to pay the expenses of experts who shall make the necessary investigations and prepare such a map. The addition to the crop of a single year, due to protection from the Hessian Fly, would repay many times all of the expense incurred. The wheat crop of Pennsylvania in 1890 was about 21,600,000 bushels. The loss of one-half of this, at 73 cents, the average price per bushel last year in this State, would be \$7,884,000.00. The question, therefore, is one of great importance, and deserves the careful consideration of the Legislature.

The Green-House Industry.

During the year this Division collected very complete statistics with regard to the "Green-House" industry of the State. Full lists of names of those who are engaged in this business were secured, after a great deal of correspondence and personal visiting on the part of the Economic Zoologist. The results show the extent which this branch of Horticulture and Gardening has reached. The following summary is taken from the Economic Zoologist's report:

Total square feet of glass in green-houses, ..	2,433,334
Total square feet of glass in cold frames, ..	226,575
Area of land cultivated, acres,	1,185
Value of establishment,	\$1,330,570 00
Amount of annual business,	652,269 00
Amount of annual expense,	313,867 00
Number of men employed,	674
Number of women employed,	22
Number of children employed,	39
Number of plants propagated,	2,076,100
Value of plants propagated,	\$42,262 00
Value of cut flower sales,	224,632 00
Value of roses sold,	90,825 00
Value of carnations sold,	51,215 00
Value of chrysanthemums sold,	12,211 00
Value of potted plants sold,	61,135 00
Value of hot house vegetables,	10,657 00
Annual loss by insects and fungous diseases,	24,516 00

This industry is rapidly enlarging, and promises in time to be one that will require and deserve the undivided attention of an expert in the Department to properly attend to its demands.

The experience of the past year emphasizes the statements with regard to this Division made in my report for 1899. In discussing the needs of the Division of Economic Zoology and speaking of its scope, the report states that: "The Division includes Economic Zoology, Horticulture, Floriculture, Market Gardening, Green-House Gardening and Nursery Inspection. It is evident from the number of subjects that this Division embraces, that no one man can possess the expert qualifications which are necessary to answer all of the questions which arise in the various lines which the Division includes. The one subject of Economic Zoology proper, is more than any one man can master in a life time of study, to say nothing

of Horticulture, Vegetable Gardening, Floriculture and Nursery Management. At least five experts should be employed in this Division to at all properly equip it."

DIVISION OF FORESTRY.

As the forests of Pennsylvania have now about disappeared, our citizens are coming to realize their great importance as entering into the wealth of the State. The accumulation of centuries of growth was present in our trees, and to the citizens of Pennsylvania, during the past forty years, this forest growth was a valuable gift, inherited or purchased at a nominal price. The wonderful development of the country during this period has made a demand for timber, which the lumbermen supplied, disposing at a profit this raw material, which required but little intermediary work to prepare for market. The professional lumberman, with his army of employes, has lost his occupation and has left Pennsylvania for other harvest fields. Since the forests have disappeared, the farmer who remains, no longer has a timber tract to enter, cut and dispose of in payment of his debts or to enrich his bank account. We have suddenly come to realize that our forests are gone, and with them has disappeared one of our most valuable sources of wealth.

We have begun none too soon to attempt to remedy the serious injury which this industry has suffered through the past reckless waste of our resources as a timber producing State. The problem of another crop is now upon us for solution, a problem of no ordinary difficulty, but one that will take years of patient, intelligent effort on the part of our public and private citizens to properly solve. A beginning has been made in Pennsylvania by the enactment of such legislation as forms a broad and strong foundation for future work.

Authority is granted to the Commissioner of Forestry for the purchase of lands, suitable for forest purposes, at tax sales, at a price not to exceed the amount of taxes for the non-payment of which the lands are being sold, together with the added costs. He has also authority, subject to the approval of the Board of Property of the State, to purchase forest lands at a price to be agreed upon and approved by the Board of Property, and not to exceed the assessed value of the property, and in no event to be above \$5.00 per acre.

The Legislature has also constituted a Forestry Commission, composed of the Commissioner of Forestry, the chairman of the State Board of Health, the Deputy Secretary of Internal Affairs, and two other persons to be appointed by the Governor. This Commission has power to locate and condemn, subject to jury damages, three reservations of not less than 40,000 acres each, upon the head waters of the Delaware, Susquehanna and Ohio rivers. The Commissioner reports that at this time the State is in possession of 40,605 acres and 99 perches, purchased under the acts of 30th of March, 1897, and April 28, 1899, and these lands are under the control of the Department of Agriculture as custodian for the State.

There have been purchased, in addition, by the Forestry Commission, under act of May 25, 1897, 57,768 acres and 12 perches, making a total of 98,370 acres and 111 perches. Additional lands have been reported to the Commission, amounting to 15,542.71, which if approved, will make the State the owner of 113,916 acres and 22 perches. The lands are situate in Elk, Lycoming, Clearfield, Clinton, Pike, Cameron, Tioga, Centre and Mifflin counties.

The proper care of the lands already purchased and of those which the State shall in the future secure, is a subject of great importance. The policy to be pursued should be carefully planned so as to avoid the necessity for change in future years, to the detriment of the interests of the State. A well considered body of principles for their management should be compiled and embodied into law, so as to prevent future Forestry Commissioners, who may be unfamiliar with the purpose of the State, from overturning the entire work of their predecessors.

A well digested plan for future guidance should be at once secured, and all efforts hereafter be directed to the carrying out of this plan in the most economical and satisfactory way. Before any forestry reservation system can be successful, there must be, first of all, an effective means for preventing forest fires. This is fundamental in the forestry question in America, and no progress can be made until this is secured. This being secured, the way is comparatively clear. Mere protection from fire will ensure in most localities a fair growth of timber in a reasonable time, without much additional care. No doubt, in time, we shall set out plantations of trees, selected with regard to their value in the arts, and to their rapid maturing characteristics. In time, also, quick growing trees will doubtless be discovered which can be cropped every fifteen or twenty years; trees adapted to special uses and cultivated to produce the qualities required in the shortest time and with the greatest certainty. Locust, hickory, chestnut, willow, poplar, linden, white pine and others not yet discovered, are examples of what

can possibly be done in this direction. Whenever such crops become possible and profitable, capitalists will invest their money in timber lands instead of bonds, and leave as a legacy to their families, thousands of acres of land which will ensure them a steady and perpetual income, and incidentally, benefit and enrich the State.

To induce investments, the tax rate on such lands should be but nominal, sufficient only to keep the property listed in the records of the county, and whenever these lands are cleared a certain percentage of the value of the product should be paid to the State for the protection afforded during the period of growth. To insure immunity from fire, it is absolutely essential that proper persons be appointed and paid to watch the reservations during the season when fires prevail, and that railway companies shall station watchmen along the lines of their road during the fire season, who shall patrol all forest districts through which railroads run, after every train. Severe penalties should be required from all, who either through intent or carelessness, are found guilty of setting out forest fires. The general public cannot be expected to give the careful and watchful attention to the prevention of fires upon the reservations that their value and importance require. The responsibility for their safety must devolve upon the owner, which is the State, and this means that the State must employ the same methods for protection that individuals find it necessary to adopt in order to secure the same end. A modern city could not exist without a regularly organized fire department, assisted by a police force that is constantly on the watch; neither can exposed and inflammable property, such as forests, be secure against evil disposed and careless persons, unless efficient guardians are provided who shall discover and arrest offenders and extinguish fires. A law, therefore, should be at once enacted which shall authorize the employment of watchmen upon the State reservations, and provide for their proper compensation adequate for the service required.

The report of the Commissioner is largely devoted to a recital of what has been done to arrest offenders and prevent forest fires during the past year. He shows how frequent and destructive these have been, and how inadequate are the means now provided to prevent them. The importance of the question, therefore, cannot be exaggerated, and all of our experience, as well as that of others, shows that this is not only the weak place in our system of forest management, but is also primary, in any plan, if it is to be effective in forest preservation and for the securing of timber growth.

DIVISION OF VETERINARY SCIENCE.

The Live Stock interests of the State are valued at over \$150,000,000.00. Previous to the establishment of the Department of Agriculture, five years ago, there was scarcely any official recognition on the part of the State of the existence of such an industry. A law did exist, passed in 1889, which authorized the Secretary of the State Board of Agriculture to take action in case of certain "contagious" diseases, but no skilled veterinarian was in charge to make constant study of the conditions that existed and to prescribe remedies to meet them. As a consequence, the spread of certain diseases among our domestic animals was practically unrestrained, and when the Department was organized and the State Live Stock Sanitary Board took charge of the work, it was found that fully 25 per cent. of the herds of cattle in the State were infected with tuberculosis, and many of the animals were in a condition so dangerous as to be a menace to the public health.

The establishment of a Division in the Department, in charge of a skilled veterinarian, at once placed the work of the care of the health of our domestic animals under expert control, and the results have shown the wisdom of this, in the decrease of the number of diseased animals and the better protection of those that are in health.

The Veterinarian reports that "the losses from disease among domestic animals have been distinctly less for the past year than for any previous year since the establishment of the Department." The Division has "nearly 300 regular correspondents through the State, and about as many more who write as occasion requires." The system of reporting, therefore, is quite complete and no outbreak of disease can occur anywhere in the State without its being immediately known by the Veterinarian and means taken to suppress it.

Much of the work of the Veterinarian has been in the inspection of herds for the detection of tuberculosis. Sixty thousand doses of tuberculin were prepared by the bacteriologist of the Division. Six hundred and fourteen herds, composing nine thousand two hundred and seventy-four cattle have been tested by this method. As many more were subjected to a physical examination. Out of this number, 1,227 were condemned as tuberculous and killed. The law

provides for the appraisement of animals found to be tuberculous, either by agreement with the owner or by three persons, one selected by the owner, one by the Veterinarian or his agent, and the other by the two thus selected. Unregistered animals cannot be valued at over \$25.00 per head, and those registered at not over \$50.00. The average appraisement for the year was \$23.10 per head.

The accuracy of the tuberculin test is now generally understood, and no difficulty is experienced in securing the consent of owners for the destruction of animals responding to the test, and there is no longer any suspicion of it producing ill effects upon healthy stock.

The law of May 26, 1897, requiring all cattle brought into the State for breeding purposes, to be accompanied with a certificate of inspection, certifying as to their freedom from tuberculosis, has, in the opinion of the Veterinarian, reduced the number of infected animals imported into the State, to a minimum. The enforcement of the law is neither difficult nor expensive, and the protection which it affords to the herds of the State is worth, according to the Veterinarian's estimate, at least \$60,000 per year.

The Veterinarian calls attention to the gross carelessness of some owners of live stock in the disposition of the carcasses of those that die of dangerous diseases, particularly such as have been affected with anthrax. The carcass is dragged over the ground, leaving the soil infected along the course, and at the end, permitting the body to decay without being covered from access by dogs or carrion birds. The persistent nature of these germs is such as to keep them alive for years, and a soil so infected is dangerous to any animal that crosses it, and germs adhering to the feet of birds or dogs are carried long distances and deposited to the great danger of animals in such localities. Legislation is recommended which shall give authority to the Live Stock Sanitary Board to require the complete destruction of such carcasses and a thorough disinfecting of all places which were contaminated by their presence.

An outbreak of glanders in the coal region was traced to a car load of mules shipped in from East St. Louis stock yards. Great difficulty was experienced in arresting the spread of the disease, for the mules were sold and distributed to several collieries before their condition was discovered. Stables had to be thoroughly disinfected and thirty-five animals killed. This example of the dangers to which the live stock interests of the State are exposed, is only one of a class that are in existence and only await opportunities to enter the State and spread destruction among our most valuable stock. It gives rise to the question, as to whether we must

not have strict inspection laws which shall apply to all classes of stock, and quarantine regulations which shall take care of all animals that are suspected of being affected with any contagious or infectious disease.

The Veterinarian also recommends that authority be given to kill dogs found at large in violation of the regulations respecting rabies. Outbreaks of this disease have occurred in several localities but were prevented from spreading by promptly quarantining the district in which the disease was found.

Sheep scab, hog cholera, forage poisoning, abortion and contagious ophthalmia of cattle, are all referred to in the report of the Veterinarian. He states that "the losses from hog cholera this year have not exceeded \$100,000.00 as against \$400,000.00 in 1897." The complete isolation of swine found diseased has brought about the more satisfactory condition.

As the reliable character and helpfulness of the work of the Division becomes known and appreciated, the duties of the Veterinarian have correspondingly increased, until now his office force is insufficient for the labor to be performed. Many persons apply for advice as to the treatment of trivial cases of diseases, which ought to be sought from practitioners in their locality. This greatly burdens the correspondence, and takes time that ought to be devoted to the more important work of the Division. To what extent this character of inquiry should be encouraged, and where the line should be drawn, beyond which it shall not go, is difficult to determine, and yet if inquiries of this nature continue to multiply in the future, as they have in the past three or four years, there will either have to be a larger increase of expert force in the office or much of the correspondence be unanswered.

At present, the laboratory work is also enlarging, as the report of the past year conclusively shows. The preparation of 60,000 doses of tuberculin, and all of the mallein and anthrax vaccine used by the Board, requires an amount of careful expert work not appreciated by those who have not seen it. Besides this, there are the investigations of specimens for identification of diseases, inquiring into the causes which have induced the disease and the discovery of and preparation of appropriate remedies.

Opportunity should be given for young veterinarians and bacteriologists, graduates of reputable colleges, to enter this laboratory and conduct research work at a small compensation, sufficient only to a little more than to pay their expenses, and thus fit these young men for the more skillful exercise of their profession, and at the same time, secure the expert services needed by the State.

The Department of Agriculture at Washington has adopted this

method, and offers inducements to young men of special skill in any department of agricultural science to enter its Divisions and continue along the line of their specialty while assisting in the particular work of the Division. This has added greatly to the reputation of the Department, and at the same time is giving special opportunity, to young men of ability, to become familiar with research work of an advanced grade.

COMMERCIAL FERTILIZER INSPECTION.

By the act of the Legislature of the 28th of June, 1879, as amended by acts of May 21 and June 26, 1895, every package of "commercial fertilizers sold, offered or exposed for sale for manurial purposes within this Commonwealth, shall have plainly stamped thereon the name of the manufacturer, the place of manufacture, the net weight of its contents, its analysis, stating the percentage therein contained of nitrogen, or its equivalent in ammonia in an available form, of potash soluble in water, of soluble and reverted phosphoric acid, and of insoluble phosphoric acid." The law further provides for the taking out of licenses and the furnishing of statements of the amount sold during the previous year. The Secretary of Agriculture is charged with the issuing of licenses, the inspection of samples and their analysis, together with the publication of the results. During the past year there were one thousand and three brands licensed, thirteen hundred and eighty-nine samples collected, and six hundred and twenty-nine analyses made. Many of the samples taken were duplicates of a given brand and were mixed and analyzed as a single composite sample. The remainder of the samples sent in by the inspectors were omitted from analysis, because of the fact that they had very recently been analyzed. The samples analyzed are classified as follows:

	Samples.
Complete fertilizers,	435
Dissolved bone,	3
Rock and potash,	64
Dissolved rock,	75
Ground bone,	47
Fertilizer salts,	5
	<hr/>
Total,	629
	<hr/>

The Department has strict regulations for the guidance and direction of its agents who are entrusted with the work of securing samples for analysis. Extreme care in this respect is necessary, for the slightest mistake on the part of an agent destroys the value of all subsequent work, and does serious injury to the manufacturer or dealer whose goods have been sampled. Manufacturers have come to regard the reports of the Department as of great value in their business, and are much concerned when the analysis shows their goods as falling below their guarantee.

Farmers and dealers no longer purchase fertilizers upon the representations of salesmen, but refer to the reports of the Department for confirmation of their statements as to the constituents and value.

Samples are collected twice each year, in the spring and autumn. The results are compiled and published for the information of all who deal in this class of goods.

The prices of the ingredients of fertilizers are revised each year from the market reports of the preceding year, and the chemists' estimate of the value of the goods is based upon these prices thus ascertained.

The schedule for 1900, as a whole, is as follows:

Schedule of Values for Fertilizer Ingredients, 1900.

	Cents per lb.
Nitrogen, in ammonia salts,	17
in nitrates,	13½
in dry and fine ground fish, meat and blood, and in mixed fertilizers,	15½
in cotton seed meal and castor pomace,	15½
in fine bone and tankage,	10
in coarse bone and tankage,	8½
Phosphoric acid, soluble in water, in bone fertilizers,	5
soluble in water, in rock fertilizers,	3
soluble in ammonium citrate, in bone fertilizers,	4½
soluble in ammonium citrate, in rock fertilizers,	2½
insoluble in ammonium citrate, in bone fertilizers,	2
insoluble in ammonium citrate, in rock fertilizers,	1½
Phosphoric acid in fine bone, tankage and fish,	3½
Phosphoric acid in coarse bone and tankage,	2

Cents per lb.

Phosphoric acid in cotton seed meal, castor pomace and wood ashes,	4½
Potash in high grade sulphate and in form free from muriate (or chlorid),	5
as muriate,	4½

Potash in excess of that equivalent to the chlorine present, will be valued as sulphate, and the remainder as muriate.

Nitrogen in mixed fertilizers will be valued as derived from the best sources of organic nitrogen, unless clear evidence to the contrary is obtained.

Phosphoric acid in mixed fertilizers is valued at bone phosphoric prices, unless clearly found to be derived from rock phosphate.

Bone is sifted into two grades of fineness: Fine, less than 1-50 inch in diameter; coarse, over 1-50 inch in diameter.

The result obtained by the use of this schedule does not cover the items of mixing, bagging, freight and agents' commission. To cover these, allowances are made as follows:

For freight, an allowance of \$2.00 per ton on all fertilizer.

For bagging, an allowance of \$1.00 per ton on all fertilizers, except when sold in original packages.

For mixing, an allowance of \$1.00 per ton on complete fertilizers, and rock-and-potash goods.

For agents' commission, an allowance of 20 per cent. is added to the cash values of the goods ready for shipment.

The mean quotations on freight from New York, Philadelphia and Baltimore to Harrisburg, in January, 1897, was \$1.68 per ton, in lots of twelve tons or over; in May, 1899, quotations by the Pennsylvania Railroad were: From New York, \$2.40; from Philadelphia, \$1.70; and from Baltimore, \$1.55; mean rate from the three points, \$1.88.

Last year the Department issued a Bulletin upon the "Use of Commercial Fertilizers," prepared by Dr. VanSlyke, of the Geneva Experiment Station, N. Y., which has had a beneficial effect, in teaching farmers their economical use and proper compounding, for various crops.

The trade in commercial fertilizers has been increasing each year, until they are now purchased by almost our entire farming and gardening population. The protection to purchasers, afforded by the annual inspection and analyses of goods offered for their use, is of great value and forms an important branch of the work of the Department.

SPECIAL INVESTIGATIONS.

"The Secretary may at his discretion employ experts for special examinations or investigations." This wise provision of the law has enabled the Department to secure the services of the best specialists for the investigation of such problems in agriculture as are brought to its attention. Valuable results have been obtained through the efforts of these expert specialists, bringing, as they do, to the solution of problems, the exact knowledge and skill required. The field of investigation in agriculture is very wide. Notwithstanding the fact that the United States Department of Agriculture and the Experiment Stations of the several States are engaged with a large corps of experts in inquiring into the underlying reasons for processes in use, and also in discovering new applications of principles already known, yet a large number of important practical questions affecting our agricultural methods are still unsolved.

During the past year experts have been at work for the Department in making investigations upon the following subjects:

The Character of Feeding Stuffs on the Markets of Pennsylvania.
Investigation into the Vitality of Seeds found in the Markets of the State.

Investigation into the Character of Milk, derived from Herds of Cows kept under Varying Conditions.

Investigation into the Best Methods of Feeding Steers for Market.

Examination and Testing of Material Best Suited for Road Ballast.

Special Investigation into the Methods in use in the Several States for the Transportation of Country Children to a Central School.

Special Investigation into the Methods pursued by Canning Factories in the Preparation of Fruits and Vegetables for Canning.

Special Investigation into the Tax System of Pennsylvania.

Special Investigation into the Qualities and Types of the Most Serviceable Horses.

Special Investigation for the Discovery of the Best Form for and Management of, a Green-house for Profit.

Special Investigation into the Influence of Smoke and Gases upon Vegetation.

Special Investigation into the Causes of Hydrophobia among Animals, and the Best Methods of Diagnosing the Disease.

These are all questions of interest and importance to agricultural people, and their proper solution will materially aid those who have to do with these special lines of agricultural industry.

FARMERS' BULLETINS.

In the act establishing the Department of Agriculture, the Secretary is directed to "publish from time to time such Bulletins of information as he may deem useful and advisable." The number of any one Bulletin shall "not exceed five thousand copies."

Ten Bulletins were issued during the year under the provisions of this act, and several more are in course of preparation. These Bulletins are prepared by persons specially qualified to treat the particular subject assigned, and careful attention is given to see that only reliable information is published, all visionary and ill-considered conclusions being excluded. As a result, the Bulletins of the Department now rank along with the best that are issued anywhere in the country, not excepting those sent out by the Department of Agriculture at Washington and by the Experiment Stations throughout the United States. The demand for some of these publications is much greater than the Department is able to meet. But 5,000 copies of any one Bulletin are permitted to be printed, and we have over 300,000 farmers to supply. Many of these publications are of the utmost value to our farmers and should be accessible to all who desire them. The Department can do no more useful work in aid of agricultural people than to place in their hands late and reliable information in regard to their occupation.

The cost to the State of publications of this character is trifling, ranging from a fraction of a cent per copy to seven and eight cents, depending upon the number of pages and the character of the illustrations. The law should be amended so as to permit the Secretary of Agriculture to print, at his option, at least 25,000 copies of any one Bulletin. Whilst this number would not supply all of the farmers of the State, it would meet, for some time to come, the most urgent demands of the more progressive and advanced agriculturists who are endeavoring to keep informed in all that relates to the improvement of their occupation. The Department of Agriculture at Washington has made the issuing of bulletins of information a leading feature of its work, reprinting from time to time

editions that have been exhausted; and they have established a separate Division to have charge of the preparation, publication and distribution of these pamphlets. The effect of this method in educating the farmers of the country is seen in every community, many being well informed upon difficult technical subjects relating to agriculture, who only a few years ago were in utter ignorance of the existence of such knowledge.

The following list of the titles of the Bulletins, published by this Department, during the past year, shows in a general way, the extent and character of the work in this direction:

- BULLETIN NO. 61. "THE USE OF LIME UPON PENNSYLVANIA SOILS." By Dr. Wm. Frear, Chemist of The Pennsylvania State Experiment Station, State College, Pa. 170 pages.
- BULLETIN NO. 62. "A SUMMER'S WORK ABROAD IN SCHOOL GROUNDS, HOME GROUNDS, PLAY GROUNDS, PARKS AND FORESTS." By Mira Lloyd Dock, Harrisburg, Pa. 33 pages.
- BULLETIN NO. 63. "A COURSE IN NATURE STUDY FOR USE IN THE PUBLIC SCHOOLS." By Louise Miller, Ithaca, N. Y. 117 pages.
- BULLETIN NO. 64. "NATURE STUDY REFERENCE LIBRARY FOR USE IN PUBLIC SCHOOLS." Compiled from lists furnished the Secretary of Agriculture by forty-eight leading Natural History Teachers in the United States and Canada. By Mira Lloyd Dock, Harrisburg, Pa. 21 pages.
- BULLETIN NO. 65. "FARMERS' LIBRARY LIST." Compiled by Mira Lloyd Dock, Harrisburg, Pa. 30 pages.
- BULLETIN NO. 66. "PENNSYLVANIA ROAD STATISTICS BY TOWNSHIPS." Giving the mileage of Roads in each Township, together with the Tax Levy, Proximity of Stone Suitable for Ballast, etc. By John Hamilton, Secretary of Agriculture, Harrisburg, Pa. 97 pages.
- BULLETIN NO. 67. "METHODS OF STEER FEEDING." A Co-operative Experiment by The Pennsylvania State Department of Agriculture and The Pennsylvania State College Experiment Station, under the immediate supervision of Prof. G. C. Watson, Agriculturist of the The Pennsylvania State Experiment Station, and M. S. McDonnell, Assistant Chemist, State College, Pa. 14 pages.
- BULLETIN NO. 68. "FARMERS' INSTITUTES IN PENNSYLVANIA," to be held under the direction of the Pennsylvania Department of Agriculture, season of 1900-1901. By A. L. Martin, Deputy Secretary of Agriculture, Harrisburg, Pa. 90 pages.

BULLETIN NO. 69. "THE ROAD MAKING MATERIALS OF PENNSYLVANIA." Their location, distribution and comparative merits; also some suggestions for the construction, maintenance and repair of Road Surfaces. By Magnus C. Ihlseng, E. M., C. E., Ph. D., Professor of Mining Engineering in the Pennsylvania State College, State College, Pa. 104 pages.

BULLETIN NO. 70. "TABULATED ANALYSES OF COMMERCIAL FERTILIZERS." From samples selected in accordance with the act of June 28, 1879. From January 1 to August 1, 1900. By the Secretary of Agriculture, Harrisburg, Pa. 97 pages.

The bulletins published during the year would, if bound together, make a volume of 773 pages, involving a large amount of painstaking labor. The demand for the Nature Study Bulletin, No. 63, has been altogether beyond the ability of the Department to meet. A copy should be placed in the hands of every school teacher in Pennsylvania.

THE LIBRARY AND MUSEUM.

The nucleus for a Library and Museum has been secured through exchanges, and by gift from public spirited citizens who are interested in the development of the Department in this direction.

The Department cannot be fully equipped for its work without a well selected library of books upon Agricultural Science, for reference by its officers, and by citizens in search of information.

A Museum showing the agricultural products and resources of the State, should also be begun at once, in order that strangers can see, at a glance, the districts best suited to the several crops which the State produces, and thus be guided in their selection of a location for their homes. An appropriation should be made to apply to this purpose. Other States, especially those of the West, have established such Libraries and Museums, to their great advantage. Pennsylvania needs to encourage her agriculture in all possible ways, and the presence of a complete Agricultural Library and Museum will do much to assist in promoting interest in the Department, on the part of citizens who are visitors to the capitol, and assist them in understanding and appreciating the splendid resources of the Commonwealth.

PUBLIC ROADS.

Quick and comfortable transportation throughout the rural districts has become so imperative as to demand the careful consideration of both the State and National Governments.

Good roads are now recognized as a necessity, if we as a people are to compete successfully with other countries where they exist. A highway for traffic which will at all seasons be in condition for use, and so constructed as to admit of loads double or treble those possible upon an ordinary road, and graded to permit the speed of vehicles to be increased in like proportion, will correspondingly reduce the cost of transportation and add to the value of all property situated along its route. This fact is now so generally understood and accepted as to need no further proof.

The question which is delaying their construction, is not one of doubt as to their advantages, but one of cost. Taxation in most of the rural districts of Pennsylvania is now as great as the citizens can bear, and any addition, no matter how excellent the purpose, will be resisted. On the other hand, good roads cannot be built without money, and in most localities the cost is very considerable.

Another difficulty in the way of road improvement is, that found in the "Statute Labor" law. The system of permitting a citizen to appear in person or by proxy and "work out" his road tax, has existed so long in this State as to now be regarded as an inherent "right." Any custom long in use is difficult to supplant, as is evidenced by the opposition to the introduction of the cotton gin and other modern improvements over the hand methods of primitive times. And this difficulty is greatly increased when those who have practiced these old methods believe that the introduction of the new, means the surrender of cherished personal rights, and also involves an increase of burden of expense. Any change proposed in our system of road construction and maintenance, is at once suspected, by many citizens, of attempting to do one or both of these things—take away a cherished right and increase the tax.

The problem, therefore, resolves itself into one of securing the money necessary to build good roads, without increasing the burden of taxation now upon country people, and also of preserving a certain amount of local control sufficient to protect the individual citi-

zen in his option of furnishing, at least, some labor, instead of money, in payment of his road tax.

In our early history, the system of "working out" the road tax was undoubtedly wise, and best suited to the conditions and the times. Our entire population practically lived in the country. As late as 1800, only a little over ten per cent. of the people of the State lived in incorporated towns and cities. Ninety per cent. lived in the country. The citizens, therefore, were equally interested in, and under great necessity for securing immediately some means of communication, however crude. The work of constructing roads was of the simplest character, requiring only the clearing off of the trees and stumps and the constructing of corduroy over swamps and quicksands. This was done and could best be done by the settlers themselves, for they were skillful in the chopping of timber and the clearing of land, and the work was performed at times which did not interfere with the cultivation of their crops. Population has changed since then. Now fifty-six per cent. of our people live in the cities and towns, and only forty-four per cent. in the country, and this forty-four per cent. have increased duties which make it impossible for them to leave their farms at seasons when road construction ought to be carried on. In addition to this, the time has now come when machinery must take the place of hand labor in road building, as it has in other industries, and the work must be performed at seasons most suitable for the construction, rather than at times most convenient for the citizens.

Better roads than formerly are also required to meet the increasing needs of modern life, and these roads necessarily cost, as has been stated, vastly more than the ungraded and ill-kept ways of years ago.

These new conditions, and increasing public needs, make a change from the old system a necessity, if we are to meet the demands of our present and prospective commerce and make the rural districts accessible at all seasons, to the conveyances and traffic which the increasing business of the country requires.

To overcome all of these difficulties, and meet all of these requirements, is the problem that confronts the legislator who is endeavoring to secure good roads. Other States, New York, New Jersey, Massachusetts, Connecticut and Maryland, have gone to work under laws distinct from each other, and each in its own way is securing satisfactory results. It has been suggested that Pennsylvania follow the plan of one or other of these States. The impracticability of such adoption is evident when we consider the radical differences that exist between the tax laws of these States and those of Pennsylvania. In many of these States, taxation on all

kinds of country property is for State purposes, whilst in Pennsylvania all real estate is exempt from this tax. In some States the county is the civil division, or unit, for road control. In Pennsylvania the township is the unit. Laws, therefore, for the construction of roads in any one of these States, would in all probability, work hardship in ours, because of these differences.

In my opinion, Pennsylvania will have to do precisely what these other States have done—construct a system of her own, adapted to her system of local government and tax conditions.

“State aid” is the solution of the problem for Pennsylvania. The money for this comes not from rural people and real estate, but chiefly from corporations and capitalists, stocks and bonds. The distribution of State aid, therefore, will not add to the farmer’s burden of tax. State aid added to the local tax, now levied, in the country districts for road purposes, will meet the conditions and secure the money needed to construct good roads. Provide, at the same time, that the money contributed by the State shall be expended by the local authorities according to directions prescribed by the State. This will ensure uniformity of plan, and hold local authority to strict account for the proper expenditure of State funds.

In order to make such a distribution of State funds possible, it will be necessary to have the local boards constituted in such a way as to possess continuous existence. To effect this, the terms of office of its members should terminate in different years, so as to keep a majority of the board always in existence, and thus preserve the continuance of the records, and ensure at all times in each locality a legal and responsible body with which the State can deal. Provide also, that the roads constructed shall not be permitted to lie neglected, but that some proper and capable custodian shall be held responsible for their preservation and good condition, and that such labor as is employed, whether paid from State funds or by credit on individual tax, shall be so controlled as to secure a dollar’s worth of service for every dollar of credit given.

The Road Commission, appointed under the joint resolution of the Legislature of 1897, will no doubt formulate such a law as will be adapted to Pennsylvania, and its recommendations, it is hoped, will carry such weight as to secure their adoption by the Legislature of 1901.

FEEDING STUFFS.

Numerous letters have come to the Department, from cattle feeders and dairymen, complaining of the character of the Commercial Cattle Feeds, upon the markets of the State. The impression prevails, that Pennsylvania has become a dumping ground for adulterated cattle feeds which have been excluded from the New England States by their inspection laws. This Department early in this year concluded to make an examination of the condition of the cattle feeds found in our markets, and accordingly appointed agents to collect samples, and had them sent to the State Experiment Station for examination and analysis. The results have not been fully compiled, but sufficient has been ascertained to indicate that the goods on sale in our State are lower in valuable ingredients than corresponding feeds in the States where inspection laws exist. The following table, received from the chemist, Dr. Wm. Frear, will be of interest as exhibiting the condition as developed by the investigation.

Comparison of Feeds Sold in Pennsylvania and Control States.

	Number of samples.	Protein.	Fat.
Cotton seed meal:			
Pennsylvania,	2	44.40	10.10
New England,	205	45.40	11.12
Linseed meal:			
Old process:			
Pennsylvania,	25	23.32	5.98
New England,	25	25.70	7.20
New process:			
Pennsylvania,	2	24.25	2.63
New England,	21	22.20	2.40
Wheat bran:			
Winter wheat:			
Pennsylvania,	5	15.19	4.26
New England,	45	15.50	4.40
Spring wheat:			
Pennsylvania,	9	14.84	4.65
New England,	53	16.10	4.90
All brans analyzed:			
Pennsylvania,	32	15.32	4.48
New England,	120	15.80	4.70

Comparison of Feeds—Continued.

	Number of Samples.	Protein.	Fat.
Wheat middlings:			
Winter wheat:			
Pennsylvania,	3	16.15	4.63
New England,	20	16.00	4.80
Spring wheat:			
Pennsylvania,			
New England,	60	13.30	5.20
All middlings analyzed:			
Pennsylvania,	40	15.39	4.60
New England,	125	17.00	5.00
Mixed wheat feeds:			
Pennsylvania,	3	14.21	3.90
New England,	219	16.00	4.70
Red Dog flour:			
Pennsylvania,	4	19.14	4.87
New England,	9	19.30	4.40
Corn meal:			
Pennsylvania,	14	8.94	4.69
New England,	17	9.50	4.00
Gluten feed:			
Pennsylvania,	12	24.72	2.84
New England,	60	20.63	3.74
Oat feeds:			
Crescent:			
Pennsylvania,	3	6.72	3.25
New England,	3	7.90	3.30
Others:			
Pennsylvania,	4	7.44	3.91
New England,	16	9.30	4.20
Corn-and-oat feeds:			
Victor (American Cereal Company):			
Pennsylvania,	3	8.05	3.59
New England,	25	9.20	3.90
Others:			
Pennsylvania,	17	8.96	4.39
New England,	29	9.44	3.75

A Bulletin, giving the entire results of the investigation will be published for the information of farmers as soon as all of the work of examination is concluded.

A law similar to those in operation in neighboring States, would doubtless protect us, in a great measure, from the frauds now possible in the sale of cattle feeds in our markets.

AGRICULTURAL EDUCATION.

It is a fundamental principle, that no progress can be made in agriculture, except as knowledge is diffused among farming people which gives information of a character applicable to their calling. The establishment in 1862, by the Congress of the United States, of colleges for giving instruction in agriculture, and later, the establishment of Agricultural Experiment Stations in the several States, was in recognition of this principle. Our own State College and Experiment Station are examples of the value of this method of assisting agricultural people, and prove the wisdom of Congress in making provision for their existence.

The educational movement in agriculture, like all educational movements in history, has begun at the top, with a few, and must work down among the masses until all are reached. The higher education in this country in agricultural lines is now well established, and it is the view of many of our most capable, earnest and progressive men, that the time has come when this same information should be made accessible to the mass of our population, and that this dissemination can best be conducted through the public schools.

This addition to the course of instruction given in the primary schools, has taken the form of the study of the natural objects, from the objects themselves. The success that has attended this method of instruction has been so marked as to compel educators to take up the question and consider what modifications of our old system are necessary in order to permit of this addition to the curriculum of studies.

The great obstacle in the way of adding to the existing course of study in the primary schools in the country, is found in the lack of time at the teacher's disposal. An investigation conducted by the Secretary of Agriculture this year into the number of classes heard by the teachers in the country schools, shows that the average for the State is about 27, which gives about eight to ten minutes to each class. It is, therefore, perfectly clear that it is impossible to add to the teacher's duties, as fixed by the present system. The only remedy possible is in a change of the system itself which will give the teachers more time.

Leaving out of the discussion the question of the possibility of making scholars, in any reasonable time, of pupils who have the slight attention which it is possible for a teacher in a country school to give, under our present system, we are met with the other

problem, of securing time for the introduction of new work. There is no way in which this can be done except through the consolidation of existing schools. The consolidation of several schools into one central school, will permit the classification of the scholars, and by this means the work, now imperfectly done by six teachers, can be thoroughly done by three. Every city and borough school is evidence of the truth of this, and when this consolidation and classification is made, it will be possible to introduce new work and to secure teachers capable of giving instruction in these new studies. Without consolidation, the country schools are shut up to the meagre educational course which they now offer. With consolidation will come the advanced work of the new education which has taken possession of every college, university and higher institution of learning in the land.

How can the consolidation be effected, is the question that first arises? The answer is, by conveying the children to and from the school in vans.

This Department has had a thorough investigation made into the working of this method in the States where it is in operation, and a Bulletin giving the results of that investigation is now in press, and will soon be ready for distribution to those interested in this subject. The examination shows that the system is not only practicable, but that it is also cheaper than the old. The children too, are protected in their health as they go to and from school and their advantages for education under consolidation are equal to those of the best town schools. The attention of educators is most earnestly requested to the consideration of this question, which is vital to the uplifting of country children and improvement of country life.

Attention is directed to the discussion of the importance of Nature Study to country children, as given in my report for 1899. Since that date, the sentiment of the farming people of the State has been expressed in the Institutes held by this Department during the season of 1899-1900. The Institutes in 57 counties voted unanimously in favor of the introduction of Nature Study into our public schools, and the same action was taken at a meeting of representatives of the various agricultural organizations of the State, held at the State College. The organizations represented were: The State Department of Agriculture, The State Board of Agriculture, The State Department of Public Instruction, The State Grange, The State Alliance, The State Agricultural Society, The State Horticultural Association, The Pennsylvania Dairy Union, The State Breeders' Association, The Guernsey Cattle Breeders' Association, The Pure Jersey Cattle Club, The State Poultry Association, and The Pennsylvania State College.

These associations at this conference, June 4th to 5th, 1900, passed unanimously the following resolutions:

"Resolved, That it is the sense of this conference that Nature Study should be introduced into the public schools of the State.

"Resolved, That this conference request from the next Legislature an appropriation of \$10,000 per year, for two years, for The Pennsylvania State College, to defray the expenses of continuing the preparation and distribution to the teachers of the public schools of the State, of bulletins and leaflets on Nature Study with special reference to agriculture.

"Resolved, That this conference urges the Legislature to provide for carrying into effect the act of June 28, 1895, providing for the establishment of township high schools.

"Resolved, That we request the State Legislature to make a sufficient appropriation for the erection and maintenance at The Pennsylvania State College, of a suitable building for the teaching of the different branches of Agriculture, including Dairying and Forestry."

Provision was also made for a legislative committee of five members "To formulate and urge the legislation asked for by the conference." The several delegations were likewise charged with the duty of presenting the matter to their several organizations and securing their active support for the work of the legislative committee.

The question is one, therefore, that is upon us for solution and must be considered by those now in position of influence and control, and whose duty it is to look after the highest interests of the whole people. Such action ought to be taken as will properly satisfy this new demand. It is the cry of country children for light and opportunity, equal to the educational advantages enjoyed by their more fortunately situated brothers and sisters in the towns.

SUMMARY OF LEGISLATION NEEDED.

LEGISLATION NEEDED BY THE SEVERAL DIVISIONS OF THE DEPARTMENT, IN ORDER TO INCREASE THEIR EFFICIENCY AND ENABLE THEM TO PROPERLY PURSUE THEIR WORK, IS PRESENTED IN THE FOLLOWING BRIEF SUMMARY.

DAIRY AND FOOD DIVISION.

Power to enjoin from selling a given article while suit is pending for violation of law.

Power to enter premises and search for adulterated goods, and take samples for analyses.

One hundred thousand dollars appropriation needed to enforce the law.

FERTILIZER LAW.

Amend by granting express authority to the Secretary of Agriculture to sue violators of the law, in the name of the Commonwealth, without having to do so through a purchaser.

FARMERS' INSTITUTES.

Appropriation of \$25,000 per year.

PUBLICATIONS.

Authority to print 30,000 copies of any one Bulletin.

Apportion 5,000 of the Annual Reports to the Department of Agriculture.

ECONOMIC ZOOLOGY.

Give authority to inspect nurseries and grant certificates of freedom from injurious insects and contagious diseases.

Authority to inspect orchards and vineyards and prescribe and enforce remedies for diseases and insect attacks. Appropriation of \$4,000 per year.

VETERINARY DIVISION.

Provision for the control of rabies by giving authority to destroy dogs and other animals found at large in violation of quarantine.

Giving authority to compel owners of animals dying of certain infectious diseases, to burn or bury the bodies and destroy the germs.

FORESTS.

Giving authority to employ watchmen to protect the reservations.

CATTLE FOODS.

Provide for the inspection of feeding stuffs, and require packages of goods to be stamped with the name of the manufacturer or dealer, and the percentage of carbohydrates and nitrogenous constituents.

LIBRARY AND MUSEUM.

Appropriation for the purchase of books and specimens for the Library and Museum of the Department of Agriculture.

CIRCULATING LIBRARIES ON NATURAL HISTORY AND FARM TOPICS.

Authority to purchase and preserve as the property of the State, Circulating Libraries on agricultural subjects, for distribution through the Commonwealth, to Schools, Farm Clubs, Agricultural Societies, and kindred agricultural organizations.

CONCLUSION.

The work of the Department, it will be seen, has been progressing in all lines of its operation. Each year the duties become greater, owing to the increasing demands of the public for information and assistance. There is urgent need just now, as has been intimated, for an increase of the force in the Division of Economic Zoology, to take up, specially, Horticulture, Market Gardening and Green-house work. A skilled expert to take charge of these subjects will have more than he can do to properly aid these important industries, and the time of the Zoologist will be also fully occupied in the work specifically entrusted to him by the law.

Acknowledgment is due to all of the Division officers and their assistants for the cordial co-operation which they may have given me as the head of the Department, and an examination of their several reports will show the vast amount of valuable work which each has done during the year.

I also wish to express my appreciation of the support which you have given me in my endeavors to administer the affairs of this Department. Your unshaken confidence, and wise counsel, under circumstances that attempted the destruction of all that every honorable man holds dearer than life itself, place me under obligations which I deeply feel, and which I deem it but just, to publicly express.

Very respectfully submitted,

JOHN HAMILTON,
Secretary of Agriculture.

REPORT OF DEPUTY SECRETARY AND DIRECTOR OF INSTITUTES.

Harrisburg, Pa., December 30, 1900.

Hon. John Hamilton, *Secretary of Agriculture*:

Dear Sir: I have the honor and it affords me pleasure to report the workings of the Division of Farmers' Institutes for the season of 1899-1900.

In order to form a better acquaintance with the various modes of farm operations, as carried on within the State, I have visited and attended Institutes and other farmers' meetings in a large number of the counties. The lessons learned from this vast field of intercourse with farmers carrying on every line of farm industry, bears upon its face the impress that the Pennsylvania farmer who has adopted approved and modern methods and brings to bear in his work mind, as well as muscle, is succeeding. He is fast learning that a comprehensive knowledge of his business is of first importance. He comes to the Institute laden with questions, such as he has met with the past season on the farm. These questions embrace matters relating to soil fertility; preserving moisture for cultivated crops during a dry season; the best manner of preparing feeds for stock; commercial fertilizers, their use, abuse and purchase; dairy management; feeding cattle for profit; sheep husbandry; swine; poultry for eggs and market; the orchard, garden, country home and its sanitary conditions; water supply; the country school, its location and surroundings, and what it should teach our children.

We find the farmers' minds very thoroughly crystallized on, at least, three questions. First, in favor of township or the central school; second, the introduction of a practical course of Nature Study, through which country children may acquire a correct and scientific knowledge of the things in nature with which they come in contact from day to day; third, an earnest demand for the prompt establishment of Free Rural Mail Delivery Routes in the densely populated farming communities of the State. It is indeed gratifying to learn of the universal satisfaction and good results attending the establishing of the routes, in increased mail matter. The daily newspaper, after a few days trial, could not be dispensed with, and thus the farmer who is brought in touch with the outside world, can study the markets daily and learn when and where to sell his farm products to the best advantage. In favor of the three above-named

questions, at Farmers' Institutes, last year, more than one hundred thousand farmers and their families voted; and it is encouraging to know that educators in State, county and township are joining together to accomplish this most important work.

We refer with a good degree of satisfaction to the work of the Institutes for the season of 1899-1900. The following table, which explains itself, is compiled from reports received from a corps of Institute Managers and Committees, also from a system of reports returned by Institute Lecturers. This report shows that there were held, in all, 322 days of Institutes, divided into 816 sessions, at which 577 State Lecturers were in attendance; 986 local speakers also were present. These Institutes had a total attendance of 149,855, as the following table will show:

ATTENDANCE AT FARMERS' INSTITUTES.

SEASON OF 1899-1900.

County.	No. of Days.	No. of Sessions.	State Speakers Present.	Local Speakers Present.	Total Attendance.
Adams,	5	13	9	21	1,725
Allegheny,	6	15	10	40	3,130
Armstrong,	5	13	9	19	2,000
Beaver,	4	9	6	10	2,300
Bedford,	5	13	9	16	1,315
Berks,	6	16	11	14	3,015
Blair,	4	10	6	3	1,411
Bradford,	3	19	12	4	2,550
Bucks,	6	15	8	19	2,855
Butler,	6	15	8	41	3,500
Cambria,	4	10	6	10	1,165
Cameron,	3	8	5	6	630
Carbon,	2	4	5	1	422
Centre,	4	10	6	11	2,340
Chester,	3	17	12	35	3,930
Clarion,	6	15	9	29	3,880
Clearfield,	4	11	6	36	2,195
Clinton,	6	17	16	10	2,260
Columbia,	5	15	9	16	3,426
Crawford,	3	25	12	39	2,475
Cumberland,	5	13	8	12	2,435
Dauphin,	4	10	6	..	1,270
Delaware,	5	14	6	11	4,296
Elk,	3	7	6	2	315
Erie,	6	14	9	21	3,385
Fayette,	5	13	9	22	1,130
Forest,	3	8	5	3	1,125
Franklin,	5	8	9	7	2,096
Fulton,	4	12	9	8	1,320
Greene,	4	10	6	6	1,375
Huntingdon,	4	10	6	18	2,650
Indiana,	6	15	9	27	2,715
Jefferson,	4	10	6	23	2,625
Juniata,	4	10	6	13	1,895
Lackawanna,	10	25	20	20	8,125
Lancaster,	10	30	12	17	3,915
Lawrence,	4	10	7	13	2,750
Lebanon,	4	9	9	4	734
Lehigh,	6	14	11	17	1,485
Luzerne,	4	11	9	4	2,881
Lycoming,	5	14	12	5	2,083
McKean,	4	9	7	3	1,490
Mercer,	6	15	8	30	3,025
Mifflin,	3	8	6	..	1,132
Monroe,	4	10	13	9	1,370
Montgomery,	6	15	14	31	6,100
Montour,	2	5	3	9	555
Northampton,	6	11	9	16	2,353
Northumberland,	4	10	6	23	1,615
Perry,	4	10	6	18	5,606
Philadelphia,	3	7	8	15	1,120
Pike,	1	2	2	..	40
Potter,	7	12	16	5	1,835
Schuylkill,	22	4	11	8	996
Snyder,	4	10	6	13	1,510
Somerset,	5	12	4	17	3,000
Sullivan,	2	5	3	4	1,125
Susquehanna,	6	16	18	20	3,346
Tioga,	6	15	13	13	2,800
Union,	3	8	6	8	980
Verango,	4	11	7	20	2,025
Warren,	4	10	7	15	2,140
Washington,	4	10	6	11	2,875
Wayne,	5	17	21	2	1,956
Westmoreland,	5	12	12	18	1,475
Wyoming,	4	8	6	11	2,000
York,	9	23	15	21	3,110
Total	222	816	577	986	149,855

COMPLETE LIST

OF

Pennsylvania Farmers' Institutes.

SEASON OF 1900-1901.

Giving the Counties in Alphabetical Order, and the Name and Address of the Chairman of Each County.

County.	Place.	Date.	Chairman of Institute Committee.
Adams,	New Oxford,	Dec. 31, Jan. 1,	A. I. Weidner, Arendtsville.
	Fairfield,	Jan. 2,	
	Arendtsville,	Jan. 3-4,	
Allegheny,	Bridgeville,	Dec. 3-4,	J. S. Burns, Clinton.
	Imperial,	Dec. 17-18,	
	Talley Cavey,	Feb. 15-16,	
Armstrong and West- moreland,	Apollo,	Feb. 25-26,	S. S. Blyholder, Leechburg.
Armstrong,	Elderton,	Feb. 27-28,	
	Worthington,	March 1-2,	
Beaver,	Frankfort Springs,	Dec. 19-20,	Thos. A. Clifton, Beaver.
	Darlington,	Dec. 21-22,	
Bedford,	Buena Vista,	Feb. 14,	W. Clay Lutz, Bedford.
	Fishertown,	Feb. 15-16,	
	Friends' Cove,	Feb. 20-21,	
Berks,	Boyerstown,	Feb. 11-12,	H. G. McGowan, Geiger's Mills.
	Geiger's Mills,	Feb. 13-14,	
	Blandon,	Feb. 15-16,	
	Kempton,	Feb. 20,	
Blair,	Martinsburg,	Dec. 31, Jan. 1,	H. L. Harvey, Duncansville.
	Tyrone,	Jan. 2-3,	
Bradford,	Gillett,	Dec. 3-4,	Hon. L. Piolet, Wysox.
	Le Roy,	Dec. 5-6,	
	Wysox,	Dec. 7-8,	
	Orwell Hill,	Dec. 17-18,	
Bucks,	Springtown,	Jan. 2-3,	Watson T. Davis, Ivyland.
	Northampton,	Jan. 12-19,	
	Middletown Grange, ..	Feb. 1-2,	
	Wrightstown,	Feb. 3,	
Butler,	Sunbury,	Feb. 8-9,	W. H. H. Riddle, Butler.
	Winfield Grange,	Feb. 11-12,	
	Portersville,	Feb. 13-14,	
Cambria,	Hastings,	Dec. 10-11,	Hon. J. J. Thomas, Patton.
	South Fork,	Dec. 12-13,	
Cameron,	Emporium,	Feb. 25-26,	J. K. Hockley, Emporium.
	Driftwood,	Feb. 27,	
Carbon,	New Mahoning,	March 1,	J. A. Werner, Weatherly.
	Weatherly,	March 2,	
Centre,	Port Matilda,	Jan. 9-10,	Col. Jno. A. Woodward, Howard.
	Centre Hall,	Jan. 11-12,	

DIVISION OF INSTITUTES—Continued.

County.	Place.	Date.	Chairman of Institute Committee.
Chester,	Byers,	Dec. 3,	Dr. M. E. Conard, West Grove.
	Cedarville,	Dec. 6,	
	Coventryville,	Dec. 10-11,	
	Unionville,	Dec. 14-15,	
	West Grove,	March 1,	
Clarion,	Salem,	Feb. 5-6,	G. T. Henry, Pilotet.
	Reimersburg,	Feb. 7-8,	
	Pilotet,	Feb. 11-12,	
Clearfield,	Morrisdale,	Jan. 4-5,	A. Judson Smith, New Millport.
	Woodland,	Jan. 7-8,	
Clinton,	Phelp's Chapel,	Jan. 1,	Joel A. Herr, Cedar Springs.
	Salona,	Feb. 23,	
	Lamar,	March 1,	
Columbia,	Mainville,	Jan. 28-29,	Hon. H. V. White, Bloomsburg.
	Bloomsburg,	Jan. 30-31,	
	Rohrsburg,	Feb. 1,	
Crawford,	Espyville,	Jan. 11-12,	Hon. M. W. Oliver, Conneautville.
	Dicksonburg,	Jan. 14-15,	
	Centreville,	Jan. 30-31,	
	New Richmond,	Feb. 1-2,	
Cumberland,	Dickinson,	Jan. 5,	B. D. Biggs, Shippensburg.
	Shippensburg,	Jan. 7-8,	
	Hoguesstown,	Jan. 9,	
Dauphin,	Linglestown,	Feb. 13-14,	S. F. Barber, Harrisburg.
	Fisherville,	Feb. 15-16,	
Delaware,	Concordville,	Jan. 28-29,	J. Milton Lutz, Upper Darby.
	Manoa,	Jan. 30-31,	
Elk,	Weedville,	Feb. 20,	Frank Simpson, Ridgway.
	Centreville,	Feb. 21,	
	St. Mary's,	Feb. 22-23,	
Erie,	West Springfield,	Jan. 16-17,	Archie Billings, Edinboro.
	Harbourcreek,	Jan. 18-19,	
	Wattsburg,	Jan. 23-25,	
Fayette,	Uniontown,	Feb. 22-23,	Prof. J. M. Hantz, Merrittstown.
	Tipecanoe,	Feb. 25-26,	
	Merrittstown,	Feb. 27,	
Forest,	Clarington,	Feb. 1-2,	Chas. A. Randall, Tionesta.
	Marionville,	Feb. 4,	
Franklin,	Orrstown,	Jan. 10-11,	C. B. Hege, Marion.
	Fayetteville,	Jan. 12,	
	St. Thomas,	Jan. 14-15,	
	Marion,	Jan. 16,	
Fulton,	Needmore,	Jan. 17,	W. C. Patterson, McConnellsburg.
	Buck Valley,	Jan. 18,	
	Warfordsburg,	Jan. 19,	
Greene,	Jefferson,	Dec. 12-13,	John H. Smith, Nineveh.
	Nineveh,	Dec. 14-15,	
Huntingdon,	Markiesburg,	Dec. 14-15,	G. G. Hutchison, Warrior's Mark.
	Calvin,	Dec. 17-18,	
Indiana,	Parkwood,	Dec. 2-4,	S. M. McHenry, Indiana.
	Ambrose,	Dec. 5-6,	
	Richmond,	Dec. 7-8,	
Jefferson,	Richardsville,	Feb. 13,	J. N. Kelly, Grange.
	Stanton,	Feb. 14-15,	
	Paradise,	Feb. 16,	
Juniata,	East Salem,	Feb. 4-5,	Matthew Rodgers, Mexico.
	Fort Royal,	Feb. 6-7,	
Lackawanna,	Madisonville,	Dec. 3,	H. W. Northup, Glenburn.
	Clarks Summit,	Dec. 4,	
	Bald Mount,	Dec. 5,	
	Fleetville,	Dec. 6,	
		Dec. 6,	

DIVISION OF INSTITUTES—Continued.

County.	Place.	Date.	Chairman of Institute Committee.
Lancaster,	New Holland,	Dec. 4-5,	Hon. W. H. Brosius, Fernglen.
Summer Insti- tutes.	Gap,	Dec. 7-8,	
	Quarryville,	Dec. 12-13,	
	Black Barren Springs,	Sept. 5-6,	
	Rutland Park,	Sept. 7,	
	Heisey's Park,	Sept. 8,	
Lawrence,	Hillsville,	Dec. 31, Jan. 1,	Samuel McCreary, Neshannock Falls.
	Plain Grove,	Jan. 2-3,	
Lebanon,	Lawn,	Feb. 20-21,	H. C. Snively, Lebanon.
	Schaefferstown,	Feb. 22,	
	Jonestown,	Feb. 23,	
Lehigh,	Jacksonville,	Feb. 21-22,	J. L. Schreiber, Hosensack.
	East Texas,	Feb. 23,	
	Cedarville,	Feb. 25-26,	
Luzerne,	Carverton,	March 4,	J. E. Hildebrant, Lehman.
	Lehman,	March 5,	
	Conyngham,	March 6-7,	
Lycoming,	Hughesville,	Dec. 19-20,	Hon. A. J. Kahler, Hughesville.
	Eagle Grange Hall,	Dec. 21,	
	West Branch Grange,	Dec. 22,	
	Warrensville,	Dec. 31,	
McKean,	Port Alleghany,	Jan. 15-16,	Chas. N. Barrett, Port Alleghany.
	Smethport,	Jan. 17-18,	
Mercer,	Jackson Centre,	Jan. 4-5,	John T. Crill, Mercer.
	Hadley,	Jan. 7-8,	
	Greenville,	Jan. 9-10,	
Mifflin,	McVeytown,	Dec. 19-20,	D. E. Notestine, Lewistown.
	Belleville,	Dec. 21,	
Monroe,	Gilbert,	Jan. 11-12,	Randall Biebing, E. Stroudsburg.
	Craig's Meadows,	Feb. 27-28,	
Montgomery,	Souderton,	Dec. 31, Jan. 1,	Hon. Jason Sexton, North Wales.
	Hatboro,	Feb. 4-5,	
	Centre Point,	Feb. 6-7,	
Montour and North- umberland,	Pottsgrove, (Northum- berland Co.),	Feb. 8-9,	J. K. Murray, Pottsgrove.
Montour,	Exchange,	Feb. 11-12,	
Northampton,	Lower Saucon,	Jan. 4,	Wm. F. Beck, Nazareth.
	Hecktown,	Jan. 5,	
	Moorestown,	Jan. 7-8,	
	Mt. Bethel,	Jan. 9-10,	
Northumberland,	Elysburg,	Jan. 18-19,	C. C. McWilliams, Elysburg.
	Watsonstown,	Feb. 6-7,	
Northumberland and Montour,	Pottsgrove, (Northum- berland Co.),	Feb. 8-9,	J. E. Stephens, Acker.
Perry,	Duncannon,	Jan. 30-31,	
	Blain,	Feb. 1-2,	Edwin Lonsdale, Wyndmoor.
Philadelphia,	Horticultural Hall,	Jan. 15,	
	Bustleton,	Jan. 16-17,	J. K. Van Etten, Milford.
Pike,	Milford,	Dec. 21,	
	Dingman's Ferry,	Dec. 22,	W. A. Gardner, Andrews' Settlement.
Potter,	Germania,	Jan. 9,	
	Harrison Valley,	Jan. 10,	
	Genesee,	Jan. 11,	
	Millport,	Jan. 12,	
	Roulette,	Jan. 14,	
Schuylkill,	Pinegrove,	Feb. 25,	W. H. Stout, Pinegrove.
	Orwigsburg,	Feb. 26-27,	
	Andreas,	Feb. 28,	
Snyder,	Middleburg,	Jan. 14-15,	J. F. Boyer, Mt. Pleasant Mills.
	Mt. Pleasant Mills, ..	Jan. 16-17,	

DIVISION OF INSTITUTES—Continued.

County.	Place.	Date.	Chairman of Institute Committee.
Somerset,	Somerset,	Feb. 8-9,	Hon. N. B. Critchfield, Critchfield.
	Elklick,	Feb. 11-12,	
	Berlin,	Feb. 13,	
Sullivan,	Forksville,	Dec. 14-15,	John W. Rodgers, Forksville.
Susquehanna,	Auburn Centre,	Dec. 7,	C. W. Brodhead, Montrose.
	Montrose,	Dec. 8,	
	Brooklyn,	Dec. 10,	
	New Milford,	Dec. 11,	
	Welsh Hill,	Dec. 12,	
	Uniondale,	Dec. 13,	
Tioga,	Wellsboro,	Jan. 2-3,	F. E. Field, Stonyfork.
	Tioga,	Jan. 4-5,	
	Nauvoo,	Jan. 7,	
	Mansfield,	Jan. 8,	
Union,	New Berlin,	Feb. 2,	J. N. Glover, Vicksburg.
	Brook Park,	Feb. 4-5,	
Venango,	Salina,	Feb. 4-5,	W. J. Magee, Oil City.
	Cooperstown,	Feb. 6-7,	
Warren,	Warren,	Jan. 28-29,	R. J. Weld, Sugar Grove.
	Columbus,	Jan. 30-31,	
Washington,	Centreville,	Dec. 5-6,	Hon. D. M. Pry, Burgettstown.
	Amity,	Dec. 7-8,	
	Claysville,	Dec. 10-11,	
Wayne,	Sherman,	Dec. 14,	Hon. W. C. Norton, Aldenville.
	Winwood,	Dec. 15,	
	Pleasant Mount,	Dec. 17,	
	Farno,	Dec. 18,	
	Bethany,	Dec. 19,	
	South Canaan,	Dec. 20,	
Westmoreland,	Ruffsedale,	Feb. 20-21,	M. N. Clark, Claridge.
	Manor Station,	Feb. 22,	
	Smithton,	Feb. 23,	
Westmoreland and Armstrong,	Apollo,	Feb. 25-26,	
Wyoming,	Tunkhannock,	Dec. 10-11,	D. A. Knuppenburg, Lake Cary.
	Mill City,	Dec. 12-13,	
York,	Airville,	Dec. 17-18,	Prof. S. B. Heiges, York.
	Stewartstown,	Dec. 19-20,	
	Hanover,	Dec. 21-22,	
	Dillsburg,	Jan. 28-29,	

Crop Report.

Our crop reports for this year embrace an almost complete list of farm vegetables, as well as fruit and live stock products of the State; and although the past year, in some respects, was discouraging to the production of a full crop, as in the case of wheat, the Hessian fly reducing the yield, possibly, fifty per cent. Apples and peaches, which early in the season gave promise of large yield, were, by the extreme heat, retarded in growth and development, and swept from the trees by high winds, also rendered this crop somewhat disappointing to the farmer. Remunerative prices have, however, been well maintained.

Long continued periods, extending over months, in which no rain fell in many of the counties of the State, cut short the yield of potatoes and corn; yet even in these sections of the State where some farmers failed, others by careful and systematic cultivation, succeeded in growing remunerative crops, thus bringing to our mind more forcibly the importance of soil fertility and thorough cultivation as a means of holding moisture under favorable conditions, and securing a profitable crop.

Summary of Crop Report.*

By comparing the Crop Report of 1899 with that of 1900, we find a marked advancement in the home market price of nearly all farm products, as the following figures will show:

	1899.	1900.
Wheat, per bushel, .....	.68	.73
Corn, per bushel, .....	.42	.48
Oats, per bushel, .....	.26	.32
Potatoes, per bushel, .....	.42	.53
Hay, clover, per ton,	8.20	11.20
Hay, timothy, per ton,	10.69	13.85
Butter, .....	.20	.22
Ewes,	3.72	3.61
Lambs,	3.22	3.26
Horses,	78.49	87.61
Cows,	33.13	33.08
Chickens, live, per pound, .....	.08	.08
Chickens, dressed, per pound, .....	.11	.12
Labor, day's work with board, .....	.80	.85
Labor, day's work without board, ...	1.11	1.15
Labor, by month, with board,	20.07	20.55
Labor, by month, without board, ...	23.95	24.76
Harvest wages, with board,	1.29	1.35

*For Detailed Crop Report see Appendix.

Reports from the Secretaries of the different Agricultural Societies show that sixty exhibitions, or fairs, were held during the year.* Exhibits in many of the departments were full, and in quality, above the average.

The management of these Societies are very rapidly learning that in order to maintain a standing with the farmers of the State, more encouragement must be given to the exhibition and competition in farm products. Hence, the more successful of these fairs the past season offered liberal inducements, by way of premiums, to those entering live stock and other products. And we feel quite safe in saying that these agricultural societies, by pursuing a wise course, may become more and more a means of encouraging and stimulating the farmers of the State in the production of a better quality of animals, fruit and cereals, etc.

Importance of Agriculture.

Agriculture may be fairly classed as the most important industry of the State, for upon the products of the soil depend those engaged in all other occupations and professions; and when we come to consider the vast amount of fertility that is annually carried away from the farms of Pennsylvania in the form of cereals, vegetables, fruits and dairy products, and consumed not only by the people of our own Commonwealth, but the enormous exports which go to make up a large proportion of the surplus in the National Treasury, and turns the balance of trade in favor of the United States, the Pennsylvania farmer here finds himself confronted with the problem: "How can we best feed the world, and at the same time, year by year, maintain and increase the fertility of the soil we cultivate?" To the solution of this problem, and a score of others of almost equal importance, the Farmers' Institute of Pennsylvania is joining with the rank and file of the farmers to practically solve. Institutes were held last year in every county of the State. The attendance and interest in some localities was indeed surprising, as evidencing the lively interest that the farmers of Pennsylvania have in this their "school on wheels." They are beginning to realize more and more that the farmer who would succeed under the conditions with which agriculture is surrounded to-day, must be a man of broad knowledge and culture; and how important it is that he should know something of Nature's laws as they enter into plant-life and the animal kingdom, in fact all the forces which he is called upon to control and direct in the cultivation of the soil.

In our last report, a request was made for an increased appropriation in order to the successful carrying on of these Institutes. This

*For List see Appendix.

year we are confronted with the problem of thousands of farmers asking for Institutes in their section of the State, who have not, as yet, been reached by its beneficial influence.

Before closing this brief report, I desire to bear testimony to the uniform courtesy and kind treatment extended to the State speakers and Institute Director, at the hands of the Pennsylvania farmers.

Respectfully submitted,

A. L. MARTIN,

Deputy Secretary and Director of Institutes.

REPORT OF THE DAIRY AND FOOD COMMISSIONER.

Harrisburg, Pa., January 1, 1901.

Hon. John Hamilton, *Secretary of Agriculture*:

My Dear Sir: I have the honor to make the following report of the Dairy and Food Division of your Department for the year 1900.

We have divided the State into eleven districts and have regularly employed nineteen agents, who are assigned to their respective districts.

We have seven chemists employed to analyze the various samples of food products taken by our agents.

We have two regularly employed attorneys located in the city of Philadelphia, one in the city of Harrisburg, one in the city of Altoona and one in the city of Pittsburg. Other attorneys have been temporarily employed in other parts of the State, when necessity has required it.

There were issued during the year, four hundred and seventy-one oleomargarine licenses, and we have received and paid into the State Treasury \$47,010.34 for the same.

We have collected by our agents and have had analyzed by our chemists and reported to the Department during the year, twenty-one hundred samples, of which nine hundred and ninety-six were found to be pure or true to name, and eleven hundred and four were found not pure or not true to name. Besides this large number analyzed by our chemists, our agents have collected and tested by preliminary or heat test, seven hundred and sixty-three samples, which were found to be pure or true to name and were not sent to our chemists. By this method we have saved the Department a large expense.

We have found that the oleomargarine law has been and is being violated. We attribute this condition to the fact that in May, 1898, the Supreme Court of the State decided the prohibitory oleomargarine law unconstitutional, so far as interstate commerce was concerned, and the present oleomargarine law not having become a law until May 5, 1899, and it having taken some time after that date to prepare the necessary form of license and other necessary papers to meet the requirements of this law, the Department was without legal power for more than one year to prevent the sale and shipment of oleomargarine into the

State, and the manufacturers taking advantage of this condition, shipped into and flooded the markets of the State; and although our agents have been active and have taken a large number of samples, and while a large number of prosecutions have been brought and some of the violators have been fined and a few sentenced to prison, the Department has been hampered and prevented by continuous processes and appeals to the higher courts, apparently for the purpose of testing the constitutionality of the color clause of the law, as in the case of J. K. VanDyke, of the city of Philadelphia. VanDyke was arrested September 13, 1899, for selling oleomargarine, colored in imitation of yellow butter, and fined one hundred dollars and costs by Magistrate Eisenbrown, of Philadelphia. Defendant appealed October 2, 1899, to the court of common pleas of Philadelphia county, where judgment for the Commonwealth was sustained January 17, 1900. From this decision VanDyke appealed March 12, 1900, to the Superior Court of the State, where the decision of the lower court was sustained April 30, 1900. From this decision he carried his appeal May 15, 1900, to the Supreme Court, where the appeal was quashed July 11, 1900. He then made a special appeal July 18, 1900, which was refused July 30, 1900, by Justice Mitchell, then, on August 6, 1900, Justice Green certified the case to the Supreme Court of the United States where it is now pending.

We also refer to the case of Owen McCann, of the city of Pittsburgh, who is a large wholesale merchant, as well as an important factor in the management of the Holland Butterine Company. McCann was arrested and a hearing was held August 26, 1899, for selling oleomargarine, colored like yellow butter, and was fined by Magistrate Cahill, of Pittsburgh, one hundred dollars and costs. From this decision he appealed September 18, 1899, to the court of common pleas of Allegheny county, where judgment for the Commonwealth was sustained December 12, 1899. McCann then carried his appeal December 19, 1899, to the Superior Court of the State where the decision of the lower court was sustained July 12, 1900. He then appealed to the State Supreme Court August 18, 1900, where, on petition of counsel of the Department, the case is advanced on the list and set for argument at Philadelphia, January, 1901, where we are in hopes we may be able to reach a decision for the Commonwealth. These continuous appeals have interfered very materially with our efforts to have oleomargarine cases come before the courts for a termination in several counties of the State, especially in the courts of the western counties, where, in Allegheny and Westmoreland counties, the courts have refused to allow any of our cases to come to trial until the decision of the Supreme Court in the McCann case is handed down. This action has also had its effect

upon the courts of other counties in the western part of the State; but while this action is being taken by our courts, dealers in oleomargarine have become more bold and continue to violate the law. Not discouraged, we are going quietly and fearlessly on having our agents take samples, having them analyzed by our chemists, bringing prosecutions and having the defendants bound to the several courts of the State, with the hope that the law will be sustained by the Supreme Court and that we may be able in the near future to bring all of our cases, now pending, to a speedy termination through the courts. While the Department has been very successful in taking a very large number of samples, one thousand and thirty-three of which have been proven by analysis to be oleomargarine, colored to resemble yellow butter, and we have arrested a large number of violators, we have been unable by our present law to compel these defendants to sell oleomargarine lawfully.

Therefore, we would respectfully recommend that our Legislature be asked to pass the following amendments, a copy of which we incorporate in our report.

We also incorporate in our report a copy of the Owen McCann appeal from the court of common pleas of Allegheny county, to the Superior Court of the State, as well as the decision in the Dffenbacher case in Erie county.

AN ACT

To regulate the manufacture and sale of oleomargarine, butterine and other similar products; to prevent fraud and deception by the manufacture and sale thereof as an imitation butter; providing for the licensing of manufacturers of and dealers in the same and providing punishment and the methods of procedure and certain matters of evidence therein for violations of the act, and the means for its enforcement.

Section 1. Be it enacted, &c., That no person, firm or corporation shall by himself, herself or themselves, or by his, her or their agent or servant, nor shall an officer, agent, servant or employe of any such person, firm or corporation, sell, ship, consign, offer for sale, expose for sale, or have in his possession with intent to sell, oleomargarine, butterine or other similar substance, article, product or compound, made wholly or partly out of fats, oleaginous substance or compound thereof, not produced from pure unadulterated milk or cream from the same without the admixture or addition of any fat foreign to the said milk or cream, and which shall be in imitation of yellow butter produced from pure unadulterated milk or cream of the same with or without coloring matter, unless such

person, firm or corporation shall have first obtained a license and paid a license fee, as hereinafter provided, nor unless the said article, product or compound so manufactured, shipped, consigned, offered for sale, exposed for sale or had in possession with intent to sell, shall be made and kept free from all coloration or ingredients causing it to look like yellow butter, not unless the same shall be kept and presented in a separate and distinct form and in such manner as will advise the purchaser and consumer of its real character, nor unless such person, firm or corporation shall in all other respects comply with and observe the provisions of this act.

Section 2. Every person, firm or corporation and every agent of such person, firm or corporation, desiring to manufacture, sell or offer or expose for sale or have in his, her or their possession with intent to sell, oleomargarine, butterine or similar substance, shall make application for license so to do, in such form as shall be prescribed by the Department of Agriculture, through its agent the Dairy and Food Commissioner, which application, in addition to other matters which may be required to be stated therein, by said Dairy and Food Commissioner, shall contain an accurate description of the place where the proposed business is intended to be carried on and the name and style under which it is proposed to conduct the said business, which name and style, shall not, in the judgment of the Dairy and Food Commissioner, be calculated to deceive or mislead the public, as to the real nature of the business proposed to be carried on, and if the said application is satisfactory to the said Dairy and Food Commissioner, he shall issue to the applicant or applicants a license authorizing him, her or them to engage in the manufacture or sale of oleomargarine or butterine or similar substance, for which said license the applicant or applicants shall first pay, if a manufacturer, the annual sum of one thousand dollars; if a wholesaler, the annual sum of five hundred dollars; and if a retailer, the annual sum of one hundred dollars; if a restaurant keeper or hotel proprietor, the annual sum of fifty dollars; and if a boarding house keeper, the annual sum of ten dollars, and the said license fee, when received by the Dairy and Food Commissioner, or his agent, shall be by him immediately covered into the State Treasury. Such license may be transferred by the Dairy and Food Commissioner, upon the application, in writing, of the person, firm or corporation to which the same has been granted, provided the transferee shall comply with the regulations made by the said Dairy and Food Commissioner in regard to the said transfer. Such license shall not authorize the manufacture or sale, exposing for sale or having in possession with intent to sell, oleomargarine, butterine or any similar substance at any other place than that designated in the application and license. After obtaining the license re-

quired by this section, the person, firm or corporation obtaining the same, shall, before beginning any business under the said license, procure from the Department of Agriculture, through the Dairy and Food Commissioner, a sign or signs, as the Dairy and Food Commissioner shall determine, which in size and lettering shall be as the Dairy and Food Commissioner shall direct, and shall be uniform throughout the Commonwealth, clearly setting forth that he, she, or they are engaged in the manufacture or sale of oleomargarine or butterine or any similar substance, as the case may be, which said sign or signs when procured shall be hung up in a conspicuous place or places on the walls of the room or store in which oleomargarine or other similar substance is manufactured or sold and the license procured as aforesaid, shall in like manner be hung up in a conspicuous place in said room or store. All licenses under this act shall expire on the 31st day of December of each year, but licenses may be granted on the first day of any month for the remainder of a year upon the payment of a proportionate part of an annual license fee. Wholesale dealers within the meaning of this act shall be all persons, firms and corporated bodies who shall sell to dealers and persons who shall buy to sell again, and all persons, firms and corporate bodies who make sales in quantities of ten pounds and over at any time, and retail dealers shall be all persons, firms and corporate bodies who shall sell in quantities less than ten pounds.

Section 3. It shall be unlawful for any person, firm or corporation or any agent thereof, to sell or offer or expose for sale, or have in possession with intent to sell, oleomargarine, butterine or any similar substance, not marked and distinguished on the outside of each tub, package or parcel thereof in a conspicuous place by a placard with the word "OLEOMARGARINE" or "BUTTERINE" and not having also upon every open tub, package or parcel thereof in a conspicuous place a placard with the word "OLEOMARGARINE" or "BUTTERINE" such placard in each case shall be printed in plain uncondensed Gothic letters not less than one inch long, and such placard shall not contain any other words thereon, and every print or roll shall be wrapped in wrappers plainly stamped on the outside thereof with the words "OLEOMARGARINE" or "BUTTERINE," and where oleomargarine or butterine or other similar product is sold from solid packages before being delivered to the purchaser it shall be wrapped by the seller thereof in a wrapper plainly stamped on the outside thereof in uncondensed Gothic letters not less than one-third of an inch long, "OLEOMARGARINE" or "BUTTERINE," and said wrapper shall contain no other words. Every manufacturer of oleomargarine and every wholesale dealer therein shall keep a book in which shall be entered accurately every sale

and shipment of oleomargarine, butterine or other similar substance, giving the date of sale and shipment; the quantity, the person to whom sold and shipped; the place to which shipped and the name of the transportation line by which shipped, which book shall be always open to the examination of the Dairy and Food Commissioner, his agents, attorneys and representatives. Every retail dealer in oleomargarine or butterine shall keep an accurate account in a book open to the examination of the Dairy and Food Commissioner, his agents, attorney and representatives, in which shall be entered the date of the receipt of all purchases of oleomargarine or butterine or any similar substance made by such retail dealer stating therein where and from whom purchased and the quantity. Every restaurant keeper, hotel keeper or boarding house keeper using oleomargarine or butterine shall have conspicuously placed upon every counter or table at which food, meals or refreshments are served to customers, a placard, plainly printed in letters, not less than one-half inch in length stating that oleomargarine or butterine is used and served to customers.

Section 4. Every person, firm or corporate body and every officer, agent, servant and employe of such person, firm or corporate body who shall manufacture, sell or offer or expose for sale or have in his, her or their possession with intent to sell, oleomargarine, butterine or any similar substance in violation of any of the provisions of this act or who shall in any other respect violate any of the provisions, shall for every such offense forfeit and pay the sum of one hundred dollars, which shall be recoverable with the costs, including the expenses of analysis by any person suing in the name of the Commonwealth as debts of like amount are by law recoverable; and justices of the peace and aldermen throughout this Commonwealth shall have jurisdiction to hear and determine all actions for recovery of penalties, with the right of appeal to either party to the court of common pleas, as provided in existing laws in suits for penalties, and all penalties and costs imposed and recovered under the provisions of this act, shall be paid to the Dairy and Food Commissioner or his agents, and by him immediately covered into the State Treasury. Any person, firm or corporation or any officer, agent, servant and employe of such person, firm or corporation, who shall manufacture, sell, offer or expose for sale or have in his, her or their possession with intent to sell, oleomargarine, or butterine or any other similar substance in violation of any of the provisions of this act shall also be guilty of a misdemeanor, and upon conviction thereof shall be punished for the first offense by a fine of not less than five hundred dollars nor more than one thousand dollars and by imprisonment in the county jail for not less than sixty days nor more than six months, and upon conviction of

any subsequent offense shall be punished by a fine of not less than one thousand dollars nor more than fifteen hundred dollars and by imprisonment in the county jail for not less than six months nor more than nine months. In any proceeding under this act, either for the collection of a penalty or prosecution for a misdemeanor, the certificate of the Dairy and Food Commissioner and the Secretary of Agriculture under the seal of the Department of Agriculture shall be accepted by the justices of the peace, aldermen and courts of record as evidence of the granting of license to manufacture or sell oleomargarine or butterine or of the fact that no such license has been granted to any particular person, firm or corporation. Whenever a suit for the collection of a penalty under the provisions of this act shall be appealed to any court of record, and whenever any prosecutions for a misdemeanor on account of any violation of the provisions of this act has been returned to the court of quarter sessions, it shall be lawful for the Dairy and Food Commissioner, his agents or attorneys, in case the person or persons who have been sued for such penalty or prosecuted for such misdemeanor, have, since the commencement of such suit or prosecution, again violated any of the provisions of this act to apply to the said court of quarter sessions or any law judge thereof by petition setting forth the facts and asking the said court to make an order commanding and restraining the person or persons so sued or prosecuted as aforesaid from further violating any of the provisions of this act until such time as the said suits for penalty or the said prosecution shall have been finally decided and determined, and thereupon the said court or any law judge thereof after such notice to such person or persons so sued or prosecuted as aforesaid to the said court or judge may appear proper after inquiring into the facts alleged in said petition, shall, if satisfied that any violation of the provisions of this act has been committed since the commencement of said suit or prosecution, make an order commanding and restraining the said person or persons from any further violation of the provisions of this act until such time as the said suit or prosecution shall have been finally decided and determined, and in case upon the final determination of said suit or prosecution it shall appear that the said person or persons had incurred the liability to payment of the penalty, for which suit had been so brought or has been duly convicted of a misdemeanor in the prosecution so commenced as aforesaid, the said court or law judge thereof shall make the aforesaid order restraining the said person or persons from the further violation of the provisions of this act continuing and permanent and any violation by any person or persons of any such restraining order of such court or judge, whether the said restraining order shall be made during the pendency of a suit for penalty

of a prosecution, as above stated, or after the final determination of such suit or prosecution in the manner aforesaid, shall be punishable as a contempt of the court, so making the said order, and the said court is hereby authorized to take such steps for the punishment of such contempt as may by law now be taken for disregarding any injunction or other order of the courts of common pleas of this Commonwealth, sitting in equity and exercising equity jurisdiction.

Section 5. The Dairy and Food Commissioner shall be charged with the enforcement of all the provisions of this act.

Section 6. The money paid into the Treasury under the provisions of this act shall constitute a special fund for the use of the Department of Agriculture in enforcing this law, and may be drawn out upon warrants, signed by the Secretary of Agriculture and approved by the Auditor General.

Section 7. All acts or parts of acts inconsistent with this act, are hereby repealed, but the repeal of said acts shall not in any way interfere with or prevent the prosecution to final termination of any actions, civil or criminal, now pending or which may hereafter be commenced for violation of said acts which has already been committed.

IN THE SUPERIOR COURT OF PENNSYLVANIA.

OWEN McCANN, { No. 119, April Term, 1900.
vs. { Appeal from Judgment of Common Pleas
COMMONWEALTH. { No. 3, of Allegheny county.

Rice, P. J.

The appellant was adjudged guilty, and a judgment was entered against him by an alderman, in a suit for a penalty for selling oleomargarine in imitation of yellow butter, contrary to the provisions of the act of May 5, 1899, (P. L., 241). He was legally licensed as provided in that act, and had complied with all the requirements of the act, except that the oleomargarine sold by him was colored yellow by the addition thereto of analyne, a foreign substance, but not injurious to health. The only defense he set up on his trial was the unconstitutionality of the act. His exceptions to the record of the alderman on *certiorari* in the court below as well as assignments of error in this court, were all to the same effect.

One of the most important, as well as familiar rules for the construction of statutes is, that a legislative intent to violate the Constitution is never to be assumed; therefore, whenever a statute is susceptible of two constructions, of which the one would make it unconstitutional, the other constitutional, the latter is to be adopted. Another elementary rule is that construction is to be made of all the parts together, and not of one part only by itself. It is the duty of the courts to take a survey of the entire statute; "for the true meaning of any passage in that which best harmonizes with the subject, and with every other passage of the statute." Another rule to be noticed is that a penal statute must be construed strictly and could not be extended beyond legislature as expressed on its face. The act of May 5, 1899, needs construction and in view of the appellant's contention that the construction he puts upon it makes it unconstitutional, all these familiar principles are to be kept in mind in determining its true scope and intent. As was said by Judge Arnold, whose judgment was affirmed in *Commonwealth vs. VanDyke*, 13 Pa. Superior Court, 434: "The act is awkwardly expressed, the sentences are very much involved, and it is difficult to know their operation by relation to each other. Perhaps a strict construction of the statute would prohibit the manufacture and sale of oleomargarine in its natural state because it looks like butter, but as the act is intended to repeal the prohibitory statute of 1885 and to authorize the manufacture as well as the sale of oleomargarine in the State, we are to give the act such construction as will afford the relief and prevent the mischief it intended to prevent. The word coloration means the act or practice of coloring, or state of being colored, but it is the act or practice of coloring oleomargarine which the act of 1889 is intended to prohibit. The use of the words "admixture or addition" in the statute indicates that the intention of the Legislature is to prohibit the imitation of yellow butter by any admixture or addition to oleomargarine during or after manufacture." We adopt this as the true construction of the act; and if we are correct in this conclusion none of the constitutional objections that have been urged against it can be sustained. As was said by the Superior Court of the United States, in construing the Massachusetts statute, which differs in no essential particular from ours, so it may be said here: "it will be observed that the statute * * * does not prohibit the manufacture or sale of all oleomargarine, but only such as is colored in imitation of yellow butter produced from pure unadulterated milk, or cream of such milk. If free from coloration or ingredients that "causes it to look like butter" the right to sell it "in a separate and distinct form in such manner as will by advise the consumer of its real character it neither restricted or prohibited." *Plumley vs. Massachusetts*, 155

U. S., 462. It is clearly shown in the opinion of Mr. Justice Harlan that the statute seeks to suppress false pretenses and to promote fair dealing in the sale of an article of food; to compel the sale of oleomargarine for what it is by preventing its sale for what it is not; to protect unwary purchasers who, without closely scrutinizing the label upon the package in which it is contained, would be induced to buy it as and for butter produced from unadulterated milk or cream from such milk. Such being the scope and intent of the statute the contention that it is an absolute prohibition of the sale and manufacture of oleomargarine, and that the title gives no notice of such legislation is not well founded. The act is what its title indicates, a regulation, not a prohibition, of the manufacture and sale of oleomargarine. We held in *Commonwealth vs. Van-Dyke* *Supra* following *Plumley vs. Massachusetts* *Supra* that such a regulation does not conflict with the commerce clause of the National Constitution; and upon the principles recognized in *Powell vs. Commonwealth* 114 Pa. 265; 127 U. S. 648 *Plumley* against *Massachusetts*, and a multitude of other cases, it cannot be declared to be an infringement of the rights of the citizen secured by Section 1 Article 1 of the State Constitution or by the 14th amendment of the National Constitution.

The judgment is affirmed.

IN THE SUPERIOR COURT OF PENNSYLVANIA.

COMMONWEALTH {
vs. { No. 214, April Term, 1900.
DIFFENBACHER. { Appeal from Judgment of Q. S., Erie Co.

The defendant was indicted and convicted in the Court of Quarter Sessions for a violation of the provisions of the act of May 5th, 1899, P. L. 241, entitled "An act to regulate the manufacture and sale of oleomargarine and butterine and other similar products, to prevent fraud and deception by the manufacture and sale thereof as an imitation of butter, and licensing of manufacturers of and dealers in the same, and providing punishment for violation of the act and the means for its enforcement." It appeared on trial that the defendant had been sued before an alderman for the penalty

prescribed by the 4th section, and he contended that this section was a bar to his conviction on the indictment. In answer to this contention the court said: "There is evidence that there was a civil suit brought for this violation of the law; but that case was appealed, and the defendant has not paid the penalty, and for that reason that would not be defense to this criminal prosecution. I am inclined to think it would be no defense if he had paid it, but inasmuch as it has been paid, I instruct you as matter of law that penal action is no defense to this criminal prosecution." It has been said that this is not the policy of the law to multiply penalties, and as a general proposition, this is true. Nevertheless, many statutes have been enacted by our legislature which provide that a person violating their provisions shall be liable to a penalty to be recovered in a civil action, as debts of like amount are recoverable, and shall also be guilty of a misdemeanor, and upon conviction be fined and imprisoned. We know of no Pennsylvania decision in which it has been held that such legislation offends against any provisions of our Constitution. This is not punishing the same offense twice. The penalty recovered in the civil action and fine and imprisonment imposed in the criminal prosecution are but parts of one punishment. As was said in *People vs. Stevens*, 13 Wendell 341, "they both constitute the punishment which the law inflicts upon the offense. That they are enforced in different modes of proceeding and at different times, does not affect the principle." See also *Bisle*, St. Cr., Sect. 171.

The other questions raised by the assignments of error have been considered and passed upon in *Commonwealth versus VanDyke*, 13 Penna., Superior Court 485, and *McCann versus Commonwealth*, ante p. Notwithstanding the earnest and able argument of the appellant's counsel, we are all of opinion that the questions are ruled adversely to their contention by the cases there cited.

The judgment is affirmed, and the record is remitted to the court below to the end that the sentence be fully carried into effect.

TABLE OF SAMPLES TAKEN.

The following table shows the condition as to the purity of the samples taken by the agents of the Department during the year. It must be remembered that the agents are instructed to omit from their samples such goods as previous analysis has shown to be pure,

and to only take new goods or suspected articles and to not submit to the chemists any samples of oleomargarine or renovated butter that shows by a preliminary or heat test to be pure butter. By this method there is saved to the Department the expense of an analysis.

Allspice, pure,	7
Butter, pure,	671
Butter, renovated,	64
Butter, oleomargarine,	1,033
Butter, color,	4
Baking powder, pure,	1
Buckwheat flour, pure,	1
Buckwheat flour, adulterated,	1
Bread,	1
Cream of tartar, pure,	18
Cream of tartar, adulterated,	1
Cinnamon, pure,	6
Canned salmon, pure,	1
Catsup, pure,	2
Catsup, adulterated,	3
Cream, pure,	1
Candy,	2
Cider,	3
Condensed milk, pure,	1
Condensed milk, adulterated,	1
Cotton seed oil, pure,	1
Cocoa, pure,	4
Cocoa, adulterated,	1
Chocolate, adulterated,	2
Coffee, pure,	3
Cheese, up to standard,	6
Cheese, below standard,	1
Cloves, pure,	3
Cloves, adulterated,	1
Extract of beef, pure,	3
Extract of vanilla, pure,	1
Extract of vanilla, adulterated,	16
Fruit syrup, adulterated,	2
Flour, adulterated,	3
Ginger, pure,	3
Ginger, adulterated,	2
Grape juice, pure,	1
Honey, pure,	3
Lard, pure,	6
Lard, compound,	2

Lemon extract, pure,	5
Lemon extract, adulterated,	20
Maple syrup, pure,	1
Maple syrup, adulterated,	1
Mince meat, pure,	3
Milk preservative,	2
Milk, pure,	75
Milk, preservaline found,	8
Milk, added water,	11
Mustard, pure,	5
Mustard, adulterated,	2
Olive oil, pure,	1
Pepper, pure,	13
Pepper, adulterated,	20
Peas, canned, adulterated,	3
Pineapple jam, pure,	2
Quince, pure,	1
Raspberry jam, adulterated,	1
Salad oil, pure,	1
Soda, pure,	1
Vinegar, pure,	31
Vinegar, adulterated,	7
	<hr/>
	2,100
	<hr/>

THE FOLLOWING ARE THE NUMBER OF CASES BROUGHT
BY THE COUNTIES DURING THE YEAR.

	Total.	Terminated.	Pending.
Allegheny,	700	31	669
Beaver,	3	..	3
Bedford,	4	..	4
Berks,	7	3	4
Blair,	34	13	21
Butler,	3	2	1
Cambria,	36	18	18
Carbon,	4	2	2
Chester,	4	3	1
Clearfield,	16	12	4

	Total.	Terminated.	Pending.
Columbia,	2	2	..
Crawford,	1	1	..
Dauphin,	9	2	7
Delaware,	18	9	9
Erie,	5	1	4
Fayette,	9	..	9
Indiana,	1	..	1
Jefferson,	1	1	..
Lawrence,	7	2	5
Luzerne,	8	5	3
Mercer,	3	3	..
Montgomery,	17	9	8
Northampton,	3	..	3
Northumberland,	4	1	3
Philadelphia,	157	4	153
Potter,	3	3	..
Somerset,	2	1	1
Schuylkill,	10	4	6
Tioga,	3	3	..
Venango,	1	..	1
Westmoreland,	16	2	14
Washington,	12	..	12
	<hr/> 1,104 <hr/>	<hr/> 137 <hr/>	<hr/> 967 <hr/>

PURE FOOD.

In pure foods, we have arrived at the conclusion that the law has been generally complied with, that it has had a beneficial effect upon food products and that the manufacturers and dealers in new articles of food stuffs have, generally speaking, shown care in first making inquiry as to whether their articles meet with the requirements of our law. We have, by the assistance of certain dealers, been able to detect violators of these products; our agents have succeeded in getting samples of the suspected parties and we have strong evidence, which we expect to bring against the parties and have them brought to justice.

It has been the object of this Division to have our agents furnish all information to the dealers of the State on the food products; to inform them when there are adulterations, and in this way protect them from buying foods that are not up to the requirements of our law.

We have distributed among the dealers over five thousand copies of the Food and Dairy Laws.

We have, as yet, taken but few samples of milk, but have endeavored to comply with all requests to do so. The samples we have taken have, in but few cases, shown adulteration, while in a very small number, preservatives have been found. We are of the opinion that the duty and power of milk investigation should be vested in the Boards of Health of all boroughs and cities.

CHEESE.

We have experienced some difficulty in enforcing the law regulating the manufacture and sale of cheese. Manufacturers have been shipping their cheese unbranded as regards name and address. Their plea has been, that to not brand it, they can obtain from three-eighths to one-half cent a pound over and above the price obtained for branded cheese.

We respectfully suggest that if the manufacturers of this State would unite and make some effort to establish a trade for their output, by deciding upon some brand under which to market their cheese, this difficulty can be overcome. We can see no reason why Pennsylvania cheese should command a less price than that of the adjoining States, as by repeated analysis, the cheese manufactured in this State has shown that it is as high, if not higher, in fat, than that of adjoining States, and the fact of their cheese commanding a higher price is, doubtless, owing to their having adopted special brands under which to market their output and that this fact has become known to the trade.

VINEGAR.

The present act regulating the manufacture and sale of vinegar has had a very marked effect in the line of improvement in this

article in our State; while reports have reached us that the law was being violated, we have been unable to locate these violators; but on the contrary, it has been shown, by samples taken by our agents and analyzed by our chemists, that the percentage of adulteration is very small.

A report has been in circulation in the public press that the law has been and is preventing the farmers' from manufacturing. That the farmers may fully understand the workings and object of the vinegar law, it becomes necessary for the Department to make a brief statement in regard to the manner by which the standard was obtained. In the first place, cider was obtained from apples from different sections of the State and of different varieties, also in different stages of ripeness; from these apples, cider was made and the vinegar from this cider was submitted to the chemists of the Department for analysis, and by that means the vinegar standard was established. You can very plainly see by this method, a fair standard was reached. The law requires that the barrel in which the vinegar is contained, shall be stamped with the date of making, that it is pure cider vinegar made from apples and the name and address of the manufacturer.

In the case of farmers who do a small business in vinegar, it does not pay them to go to the expense of having this stamp made, therefore, by attaching a suitable sized card on the head of the barrel upon which the requirements of the law are written, they will meet with the requirements of the law. Any honest farmer who makes vinegar from cider obtained from apples unwatered or adulterated that has had sufficient age to make the required acidity, need have no fear of prosecution. This law was established for the purpose of protecting the farmer and consumer and to prevent fraud from manufactured vinegar, and since this law has been established, it has proven a great benefit to the honest farmers and has had the effect of checking, to a great extent, the sale of artificial vinegar throughout the State of Pennsylvania.

EXPENSES.

As the oleomargarine law reads, all moneys received for licenses and fines must be paid into the State Treasury for the use of the Dairy and Food Commissioner for the enforcement of the oleomargarine law, and as, up to this time, the whole expense of the en-

forcement of this law has been paid from this fund, and if the higher courts sustain the constitutionality of the law, then the number of licenses will decrease and our income from that source will be diminished.

We would respectfully recommend that the appropriation to the Dairy and Food Division for the next two years be increased.

REPORT OF THE ECONOMIC ZOOLOGIST.

Harrisburg, Pa., January 1, 1901.

Hon. John Hamilton, *Secretary of Agriculture, Harrisburg, Pa.:*

My Dear Sir: I have the honor to submit herewith the following report of work of the Division of Zoology for the year ending December 31, 1900.

The work of the office has been quite extensive. An unusually large number of injurious insects have been reported, especially those injurious to fruits and fruit trees, with requests for identification and best methods for control and extermination. Fruit growers are awakening to the fact, that, in order to successfully conduct their business, the San José Scale must be held in check. To exterminate it completely is about impossible. The Division is in receipt of information where entire orchards, especially peach orchards, have become polluted with the scale, the number of trees affected running into the thousands. Judging from the reports received, all hope of successfully exterminating the scale has been abandoned. It has been the purpose of this Division to disseminate information that will keep this scale under control in fruit growing districts in Pennsylvania, but from personal investigations which have been made, and from information that has been acquired from other sources, this seems now to be out of the question, unless the Legislature will enact such laws as will prevent the spread of the scale through infected nursery stock.

There are many sections in this State, especially in the western and northwestern counties where the scale has not yet appeared, at least no reports of its presence have yet been received, and these localities may be kept free by the adoption of proper protective legislation.

The careful examination of nursery stock cannot be too strongly urged upon prospective buyers, as it is in this manner that the scale is frequently introduced into localities that heretofore have been free from this pest. There is, in my opinion, but one successful way of preventing the spread of the San José Scale and other dangerous tree diseases throughout the State, and that is the method already intimated, namely, the enactment of legislation requiring the inspection of nurseries, the placing on file in this Division of the certificate of inspection, and the sending with each shipment a duplicate certificate of inspection, stating the stock to be free from all dangerous insects and fungous diseases. By making these provisions

the young stock can, at least, be started free from disease, and it then devolves on the grower to keep it in this condition. Complete extermination of the scale is possible only when it is first discovered, and before a chance has been afforded for it to spread to any great extent. The only sure method of complete extermination in any case is that of digging up and burning the infected trees. This has been advised in several instances by this Division, when the trees were old, and almost past the bearing age, and also when the nursery stock, lately introduced, is badly infested.

Lecanium, of several species, yellows, black knot and pear blight have also been reported from different localities. Prompt treatment has been advised and, in most instances, with satisfactory results.

The Division is also in receipt of information relative to the destruction of quantities of grain by the Angoumois moth (*Gelechia cerealalis*). The greatest losses from the ravages of this insect seem to be confined, more particularly, to the eastern section of the State, especially in Bucks, Montgomery and neighboring counties. Our correspondence shows that a very large percentage of many wheat crops has been destroyed by this moth. One miller reports "that it takes at least five and one-half bushels of wheat to make one barrel of flour, and that, of course, of a very poor quality." Upon further investigation by this Division, the cause for much of this loss can be attributed to delay in threshing after the grain has been harvested. The storing of the grain in the stack or barn permits continuous breeding to proceed until checked by cold weather. By early threshing, the only difficulty will be with the first brood of the moth in the fields. Information regarding the habits, life history and treatment of this insect has been supplied and good results are expected.

The Walking Stick (*Diapheromera femarata*) has been reported from Columbia county by Prof. D. S. Hartline, of the Bloomsburg State Normal School. A very interesting description of the result of an investigation is given in the school paper, from which the following is taken. "I questioned the farmers about the times of their appearance in such vast numbers in this section. According to their observation there were very few last year. And the only time previous to this when they were extremely abundant was six years ago. I inquired also about the extent of territory covered this year. The information obtained is somewhat vague. From what we saw and from what they said, I feel that it is safe to say that several square miles are covered, but only the vegetation on the hill tops. The trees and bushes in the valley are not affected, as yet, though Mr. Lutz reports finding them very abundant some distance up the Lick Run Valley, in the trees and shrubs overhanging the brooks." The article further speaks of the ignorance and indifference of the farmers whose timber is being destroyed in this manner, and says: "A signal illus-

fration of the immense losses sustained yearly by the agricultural industry of the State because of the ignorance of the farmers about the matters that concern them most. It would be hard to convince such farmers that leaves are very necessary organs of the trees, and that a tree cannot often survive entire defoliation." The only practical way to exterminate this pest is to burn over the tract, thus destroying the eggs before they have sunk into the ground.

The correspondence of the Division has been quite extensive, many hundreds of letters having been received and answered. Requests for bulletins, treating on different subjects relating to plant diseases are received almost daily, and a large number of the laws controlling dangerous fruit tree diseases, have been sent out.

The following bulletins have also been sent out: Bulletin No. 56, "Nursery Fumigation, and the Construction and Management of the Fumigating House," by Prof. W. G. Johnson. These were sent to the nurserymen and florists of the State. There are on file in this Division the names and addresses of 1022 of these.

Bulletin No. 58, "A Chemical Study of the Apple and Its Products," by C. A. Browne, Jr., was forwarded to the orchardists and fruit growers, of which the names and addresses of over 30,000 are now on file. It was necessary, however, to limit the mailing list to one-tenth this number owing to the inadequate appropriation set apart for this purpose.

Bulletin No. 59, "Fungous Foes of Vegetable Fruits," by Prof. Byron D. Halsted, Sc. D. was sent to market gardeners, the mailing list showing 3,081 names and addresses to be on file.

The results obtained from the sending out of circulars to fruit growers requesting information regarding the extent of fruit growing in Pennsylvania, gives some idea of the extent of that industry. Three thousand circulars were sent out and replies were received from a little over one-third of them. The statistics derived from these replies shows this industry to be more extensive, both as to the acreage covered and the profit derived from the sale of the fruit, than is commonly believed. These statistics are, however, incomplete as yet, and it is necessary to defer giving them until a later report.

The following circular of inquiry was sent to the florists of the State in order that the Department of Agriculture might acquire some information as to the extent of floriculture in Pennsylvania, also for the purpose of disseminating information regarding the eradication and control of injurious insects and fungous diseases:

"Dear Sir: The Division of Zoology of the Department of Agriculture, desires to gather some statistics with regard to the condition of floriculture in Pennsylvania, with a view of assisting those

who are engaged in this industry, by disseminating such important information as the Department may be able to secure. The following list of questions, is, therefore, sent with the request that you answer them so far as you may be able, and return this paper in the enclosed envelope, to the Division of Zoology, Harrisburg, Pa.

"Answers to any questions relating to your personal business, will be regarded as strictly confidential, and will not be published separately, being only used in the aggregate to discover the total for the State. When the results are compiled, a copy will be mailed to your address.

"Very respectfully,

"Give total sq. ft. of glass in green houses. Give total sq. ft. of glass in cold frames. Give area of land cultivated. Give value of establishments. State amount of annual business. State amount of annual expense. What is your system of heating? Give number of persons employed—men, women and children. Are your houses used for propagating exclusively? If so, what plants do you propagate? How many of each kind annually? Give approximate value of kinds propagated last year. State total cut flower sales. State total sales of roses. State total sales of carnations. State total sale of chrysanthemums. State total sale of potted plants. Do you raise hot house vegetables in connection with your business as a florist? State kinds. Name amount of each. State value of each. Are you troubled with insects? By what kinds? Name insects doing most damage. What are your most troublesome fungous diseases? Do you fumigate? What materials do you use and how? State results. Do you spray? What materials do you use? State results. Have you any other successful method of destroying injurious insects or fungous diseases? What method in your opinion is best? State annual loss as nearly as possible by insects and fungous diseases. Give name and address of new florists in your vicinity. Remarks "

The results obtained from these circulars are very satisfactory, although the number of replies received were less than one-fourth of the number of circulars sent out. (For tabulated statement see Appendix.)

The hot water system seems to be used more than any other, with steam and hot air following in the order named. None were exempt from the attacks of insects and fungous diseases, the loss from which appears in the table, and is at least 8 per cent., which indicates a loss of many thousand dollars annually.

It is the purpose of this Division to secure additional statistics from the florists during the coming year, and also from market gar-

deners, for the use of the Department, and to furnish correspondents in return with such matter as will very materially diminish the loss by injurious insects and fungous diseases.

Great credit is due Mr. Frank S. Chapin, clerk of the Division, for the efficient manner in which the statistics for this report have been collected and compiled. I append herewith, as part of my report, a brief history of the habits and characteristics of a number of the more destructive insects, together with the most effective methods for their extermination.

Very respectfully,

BENJAMIN F. MacCARTNEY,
Economic Zoologist.

SOME INSECTS INJURIOUS TO STORED GRAIN AND CEREAL PRODUCTS.

Stored grain is subject to injury by insects of several kinds. Some of these live entirely within the kernel of the grain, while others live on grain in the kernel, also when manufactured into flour, meal and feed as well as on various other cereal products. Grain stored away in the fall may become so badly infested by spring that its value as food is greatly reduced, and for seed purposes it is almost worthless. The weight of grain infested with insects soon becomes greatly reduced from the fact that the nutritious substance has been eaten out, leaving nothing but the hulls. Aside from the loss in weight occasioned by the ravages of insects, grain infested by them is unfit for human consumption, and has been known to cause serious illness, and is not even desirable for food for live stock. It is known that grain infested by the Angoumois moth for six months has lost fifty per cent. in weight, and seventy-five per cent. in farinaceous matter. Fortunately there are remedies against these insect pests. The carbon bisulphide treatment has been used with the best success against all kinds of insects infesting stored grain and cereal products. Complete directions for its use will be found in the treatment suggested for the Angoumois moth.

THE ANGOUMOIS GRAIN MOTH.

(Sitotroga cerealella Oliv.)

The probable origin of this insect is in the Mediterranean region, and takes its name from the province of Angoumois, France. It was subsequently introduced into the United States, and has since spread over a vast amount of territory doing the most damage, however, in the tropical and warmer temperate localities. It not only infests wheat but also corn, barley, buckwheat, chick-peas and, it is said, cow-peas.

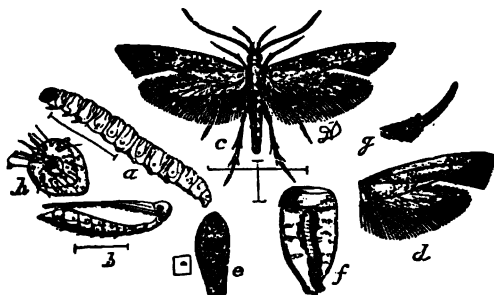


Fig. 1.

Angoumois grain moth, *Sitotroga cerealella*: a, Larva; b, pupa; c, moth; d, wings of a variety; e, egg; g, h, structural details very much enlarged; f, larva feeding in kernel of corn. (After Riley.)

LIFE HISTORY.

The winter is passed in the larval stage in the kernel of the grain or corn. The little caterpillar when fully grown is about one-fifth of an inch long, white in color with a yellowish hard head, and after eating to the surface of the grain, but not through it, the larvae spins a thin covering of silk, and when warm weather sets in, changes to a pupa and emerges as a moth about the time the wheat comes into head.

The moth greatly resembles the familiar little clothes moth so frequently seen in houses and is about the same color and size.

The eggs are laid upon the grain, each female placing from 60 to 90 eggs in lots of about 20 each. The eggs are very small, of orange color and hatch in from 4 to 7 days. The little caterpillars soon bore into the kernels and mature in about three weeks, and the second brood of moths appear a little before harvest. The eggs from the second brood are then laid, either in the ripe grain just before harvest, or after the grain has been stacked. The larvae which are then in the grain, mature early in September and under normal conditions remain there until the following spring; however, when the season is continued dry and warm there appears a third brood of moths, these usually appear after the grain has been shocked or put in mow, and of course have no inclination to fly to the fields, but lay their eggs about the middle of September, selecting the easily ac-

cessible open ends and top. Under favorable conditions, a fourth brood is hatched in the mow during October, and it is generally this brood that attracts the most attention, as it is about the time the grain is threshed.

The attack on corn is made usually after it has been husked, as the moth cannot easily make her way through the husk to reach the ear. Corn husked late in the fall and stored out doors is rarely injured owing to the low night temperature. Aside from the loss in weight, the grain, when badly infested, becomes unfit for milling purposes.

REMEDIAL MEASURES.

Thresh as soon after harvesting as possible and store in tight bins, or good sacks. The threshing kills many of the insects and rubs off the egg. Examine the grain in the bins and sacks from time to time and if it heats perceptibly, it denotes a considerable percentage of infestation and should be treated. This can be done by the following method: Measure the bin containing the infested grain, computing it in cubic feet, and for every five hundred cubic feet of space, evaporate one pound of carbon bisulphide. Place the liquid in shallow plates (soup plates are good), on top of grain, cover with some tight material as canvas, and allow same to remain covered for twenty-four hours. If none of the grain is used for seed the covering can remain for forty eight hours, as it will not harm the grain for food. It is very important that the development of the moth in the spring be prevented as far as possible, so that the fields may not become infested before harvest. Clean up all the old grain early in the spring. Let the chickens pick up all the scattered grain about the bins, and let them work over the places where the grain has been in shock.

In using bisulphide of carbon care should be exercised as it is very inflammable, and no fire should be brought near it.

THE GRANARY WEEVIL.

(*Culandra granaria*, Linn.)

This insect is strictly an indoor species, being wingless, and has been known as an enemy to stored grain since the earliest times.

The adult weevil is of a chestnut brown color and about one eighth of an inch in length. The larva (b, in Fig. 2) is legless, very fleshy and white in color. It is this larva that causes the damage to the grain, although the adult weevil also feeds upon it. The female makes a little hole in the grain, in which an egg is inserted; after the larva is hatched it devours the mealy interior and undergoes its transformation within the hull. There are several generations during the

year, the number depending upon climatic conditions, and it has been estimated that one pair will, in the course of a year, produce 6,000 descendants.

The bisulphide of carbon treatment, as suggested for the Angoumois moth, is also applicable for this insect. It is also suggested that sheets of brown paper saturated with melted lard, on which Paris green or white arsenic has been dusted, be placed on the floor and shelves of rooms infested by these weevils.

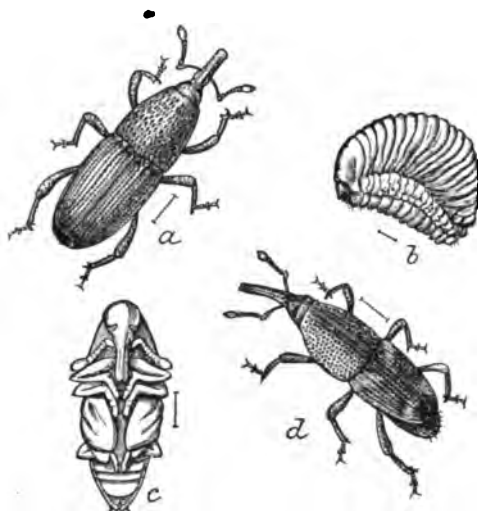


Fig. 2.—*Calandra granaria*: a, beetle; b, larva; c, pupa; d, *C. oryza*, beetle;—all enlarged.

THE SAW-TOOTHED GRAIN BEETLE.

(*Silvanus surinamensis*, Linn.)

This little beetle is a very common occurrence in granaries and wherever edibles are stored. It takes its name from its saw-like teeth.

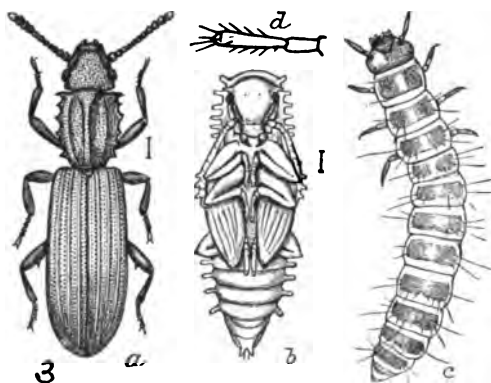


Fig. 3.—*Silvanus surinamensis*: a, adult beetle; b, pupa; c, larva—all enlarged; d, antenna of larva—still more enlarged.

The adult (Fig. 3a), is only about one-tenth of an inch in length, flat and of a dark brown color, while its larva is nearly white, with six legs and an abdominal proleg. They are very active and when discovered will scamper off in great haste. After the larva has attained its growth it attaches itself to a convenient surface, and forms a covering composed of small grains and fragments of in-

fest material, and with this covering the pupa and adult states are assumed. There are usually four generations, and during the warmest months only twenty-five days are required to make the life cycle. It is nearly omnivorous, infesting grain, flour, meal, dried fruits and seeds, and it is said that the beetles will feed upon sugar,

starch, tobacco and dried meats. Where granaries are infested, the same remedy suggested for the Granary weevil is also applied to this insect.

THE BEAN WEEVIL

(*Bruchus obtectus*, Say.)

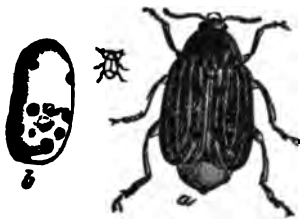


Fig. 4.—*Bruchus obtectus*. Say.: a, adult beetle; b, infested bean. Natural size indicated by small figure.

This weevil is distributed over all portions of the United States and often does serious damage. One often finds beans with numbers of excavations in them which are caused by this insect, shown in Fig. 4 (b). The adult is a small brownish beetle, about one-tenth of an inch in length. The body is hard and somewhat flattened. The female lays her eggs inside the pod, this being accomplished by the adult gnawing a narrow slit along the ventral suture, through which the ovipositor is thrust and the eggs deposited. In about a fortnight the eggs are hatched and the larvae, or little grubs, eat into the bean. A number of the larvae are often found in a single bean. These insects are also able to develop in dried beans, the various periods lasting longer in the winter than in the summer, and the eggs in this instance are laid on the outside of the bean, loosely attached. Many successive generations may be raised in stored beans. Beans infested by these insects should be placed in air tight vessels into which a little carbon bisulphide or benzine has been placed. The fumes of these gases will destroy the beetle. Late planting of the crop has been found a good way to prevent the injury, field beans being planted from June 20th to July 10th, with good results. If the beans, as soon as ripe, are heated to 145° Fahrenheit, the partially grown larvae will be destroyed, without injury to the germinating qualities of the seed.

THE PEA WEEVIL

(*Bruchus pisi*, Linn.)

This small beetle (Fig. 5 b), is very similar in life history and habits to the bean weevil. The pea probably suffers more from this insect than from the other, and is familiar to all as the "pea bug." The eggs are deposited by the adult female on the young pods, soon after they have begun to form. As soon as hatched the young larvae eat into the interior and enter the soft peas within, only one grub, however, occupying one pea. Peas thus affected will germinate, but the

growth of the plant is greatly retarded owing to a lack of proper nourishment. "When full grown the larvae eats a hole on one side of the pea leaving only a thin outer covering," before changing to a pupa. Soon after it changes to the perfect beetle, some of which



emerge in the same season, the majority, however, remaining in the peas until spring.

The same remedies suggested for the bean weevil are equally applicable to this pest. At the time of ripening the larvae are only partially grown, therefore, after heating the peas to 145° Fahrenheit, is especially advisable in the case of the pea weevil.

THE MEDITERRANEAN FLOUR MOTH.

(*Ephestia kuehniella*, Zell.)

This moth was first discovered in Germany, subsequently making an appearance in the United States, and was reported as injurious in Pennsylvania in 1895. The adult is of a grayish color with a wing expanse of less than an inch. The caterpillar (Fig. 6 c) is white and



Fig. 6.—*Ephestia kuehniella*: a, moth; b, same from side, resting; c, larva; d, pupa—enlarged; e, abdominal joint of larva—more enlarged.



Fig. 7. Larva, dorsal view.

hairy. The chrysalis (Fig. Od) is of a reddish brown color. It is the little caterpillar that does the greatest damage. They form little silken tubes in which they feed, and it is this web spinning that renders them so injurious where they obtain a foothold. After the caterpillar attains full growth it leaves its silken web to find a suitable place to undergo its transformations, and it is while searching for a place that it becomes most troublesome. The infested flour becomes lumpy, the machinery becomes clogged, resulting in the loss of thousands of dollars, in the larger establishments. While the

larvae seems to prefer flour or meal, it also attacks grain and cereal foods, and in some sections lives in the hives of the honey bee. About five weeks are required for the insect to pass through all its stages from egg to adult, and in outdoor life there are probably not more than three generations. However, in well heated mills six or more generations may be produced. When a mill is found to be infested, the entire building should be fumigated, and in case a whole district becomes overrun the greatest care must be observed not to spread the infection. Uninfested mills should be tightly closed at night, and every bushel of grain, every bag or sack brought into the mill, subjected to a quarantine process, by being disinfected either by heat or carbon bisulphide.

THE INDIAN-MEAL MOTH.

(*Plodia interpunctella*, Hbn.)

This insect feeds on meal, flour and grain of all sorts, dried fruits and herbs, and is often seen flying about in mills and stores, and its ravages are almost equal to that of the grain moth and granary weevil. The adult moth shown in Fig. 7 (a) has a wing expanse of

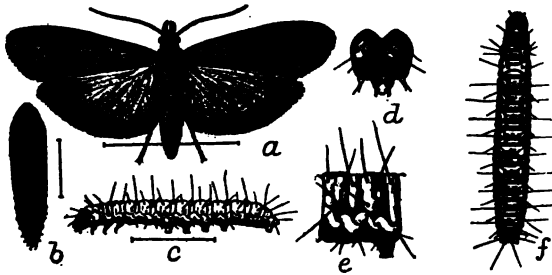


Fig. 7.—*Plodia interpunctella*: a, moth; b, chrysalis; c, caterpillar; f, same dorsal view—somewhat enlarged; d, head, and e, first abdominal segment of caterpillar—more enlarged.

about five-eighths of an inch. The inner third of the fore wings is of a dirty white, and the outer two-thirds are reddish brown. The body is rather stout for moths of this group. The larvae is a small whitish worm with a brownish head, living within the silken tubes which it spins through the meal or other material which it may infest. The infested meal becomes clotted and lumpy from these silken threads binding together, and as they also deposit large quantities of excrement which becomes attached to the silk it will be seen that they injure both for seed and food many times the amount of grain actually consumed. The eggs are also laid by the moth in the material on which the larvae feed. In a moderately cool granary or store house, four or five broods is probably the normal number per annum,

while a well heated atmosphere makes six or more generations a possibility. It requires about five weeks to complete the life cycle. The same remedies suggested for Angoumois moth are applicable for this insect. In granaries or store houses where this insect is especially troublesome, a lantern set over a tub containing water and a thin film of kerosene oil, will destroy vast numbers of the moth, but will not kill the worms in the grain.

THE CONFUSED FLOUR BEETLE.

(*Tribolium confusum*, Duo.)

This is one of the most important of the flour beetles. It is about the size of the grain weevils and is frequently associated with them, and is of nearly universal occurrence in grain of all kinds following the attacks of the latter species. With the exception of the Mediter-

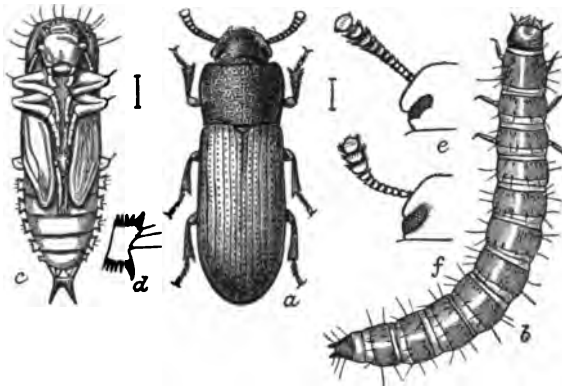


Fig. 8.—*Tribolium confusum*: a, beetle; b, larva; c, pupa—all enlarged; d, lateral lobe of abdomen of pupa; e, head of beetle, showing antenna; f, same of *T. ferrugineum*—all greatly enlarged.

ranean flour moth, it is probably the most injurious insect we have to prepared cereal foods. Its principal damage appears to be to flour and other articles of diet containing starchy matter. Among the many other substances attacked are snuff, baking powder, peas, beans and nuts. It sometimes also invades cabinets of dried insects. It is one of the most troublesome of mill pests and annually costs the millers of the United States thousands of dollars by its presence in manufactured products.

It has been learned that this species, in an exceptionally high temperature, is capable of undergoing its entire round of transformation in thirty-six days, in spring and autumn weather it requires a much longer time. In well heated buildings there are at least four broods a year.

SOME INSECTS INJURIOUS TO SHADE TREES.

THE IMPORTED ELM LEAF BEETLE.

(Galerucella luteola, Mull.)

The chief insect enemy of the elm is the imported elm leaf beetle. This insect makes its appearance early in the spring, just as soon as the leaves begin to appear, and sometimes as soon as the buds begin to unfold. The beetle (Fig. 9 k) is oblong in shape, of a yellowish

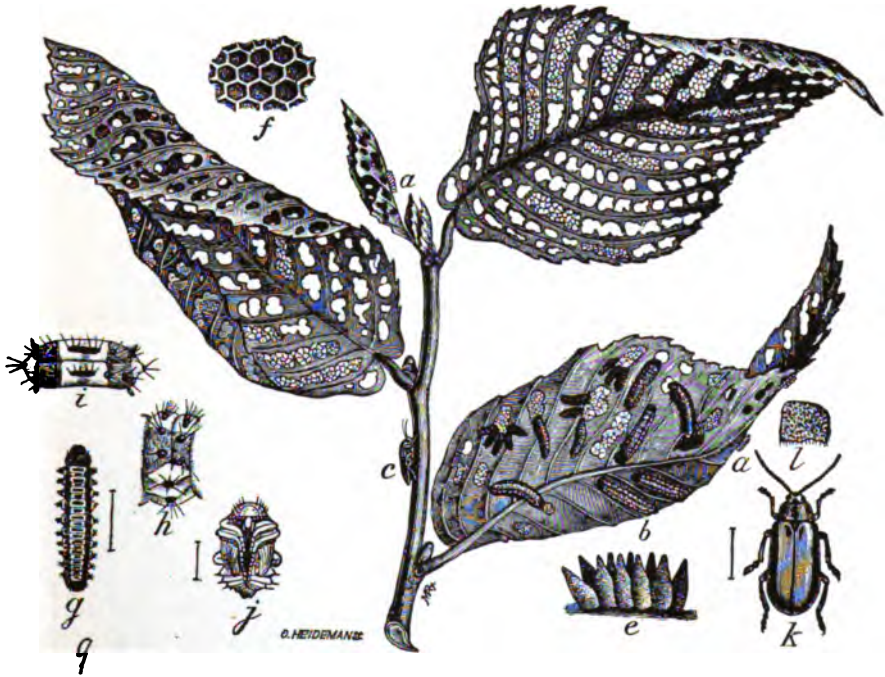


Fig. 9. *Galerucella luteola*: a, eggs; b, larvæ; c, adult; d, eggs (enlarged); e, eggs (enlarged); f, sculpture of egg; g, larva (enlarged); h, side view of greatly enlarged segment of larva; i, dorsal view of same; j, pupa (enlarged); k, adult (enlarged); l, portion of elytron of beetle (greatly enlarged). (From Riley, in Ann Rept. Dept. Agr. for 1883.)

brown color, and about one-fourth of an inch in length. It appears first and fills the leaves with small irregular holes in the more mature leaves. These increase in number as the leaves develop, until the tree looks as if loads of small shot had been fired through it in every direction. About the first of June the female lays her eggs, which are oblong in shape, and patches of these eggs can be seen on the under side of the leaves in all parts of the tree. After the eggs are laid the beetles disappear and are succeeded by the larvæ, which soon begin to hatch from the early laid eggs. These of course rapidly increase in number, and unlike the beetles, do not eat the entire leaf tissue, but feed on the superficial layer of cells either on the

upper or under surface of the leaves. This injury to the leaf causes it to turn brown and die, and eventually becoming dry it falls to the ground in midsummer. These larvae when full grown are about three-eighths of an inch in length, of a blackish color, and yellowish underneath, furnished with little black tubercles, giving rise to tufts of stiff blackish hair. They cease feeding in about thirty days and make their way to the ground, where among the grass and rubbish they cast their larval skins, and appear as soft yellow pupae. Thousands may be found about the base of a medium sized elm. In about a week or ten days the new beetles begin to make their appearance, gradually increasing in number until August when they begin to seek winter quarters. For this purpose the beetles frequently enter houses and barns or outbuildings, and often assemble in great numbers. They also enter cracks in posts and fences, or wherever they can secure partial protection from winter storms. The beetles show a decided preference for European elms over the American species, on account of the leaves of the former being so much thinner and smoother, and not so distasteful as the American elms. All species of elms are, however, subject to attack and in the absence of the favorite varieties, the injury to the less palatable sorts becomes almost equally marked. These insects can be controlled in nearly every stage of their life history by two or three sprayings with arsenical poisons. The adults, after emerging, feed on the newly expanded foliage, and spraying with Paris green or London purple will destroy a great number of them. If possible, it is of importance that the insect be destroyed in the adult stage, in order to prevent the partial disfigurement which will result if the matter be delayed until the larvae begin to appear. Paris green is the best arsenical, and may be safely used on elms at the rate of one pound to 100 to 150 gallons of water. If London purple is used, an amount of lime equal to the poison in weight should be added to prevent scalding of the foilage. As stated before, the spraying should be done when the beetles are beginning to feed in the spring, when the little holes in the leaves are first noticeable. This kills off the insect before the eggs are laid. The second spraying should be done as soon as the larvae begin to hatch from the eggs, which can be known by the scraped appearance of the leaves. As egg laying and hatching continue through a long period, a third spraying, ten days after the second, is advisable, especially if it rained during the interval. On large trees it will be impossible to reach all points so as to kill all the insects, and some will make their way to the ground to pupate. When this is noticed, a strong brine of whale-oil soapsuds or hot water, should be poured around the base of the trees, and repeated at intervals, as long as new additions are noticed.

THE WHITE MARKED TUSSOCK MOTH.

(*Orgyia leucostigma*, S. & A.)

This insect attacks almost every variety of shade, fruit and ornamental trees, with the exception of those bearing cones. The caterpillars are found scattered all over the trees in June, move about freely, and when suddenly disturbed, they drop from their perch, suspended by a silken thread which is attached to the leaf from which they started. The larvae hatch about May and cast their skin five times, showing a different character after each molt. The newly hatched larvae feed on the under surface of the leaf producing a skeletonized appearance. This feeding continues through the different molts, until finally everything is devoured except the principal veins. When full grown (Fig. 10 a) it is a very pretty creature and

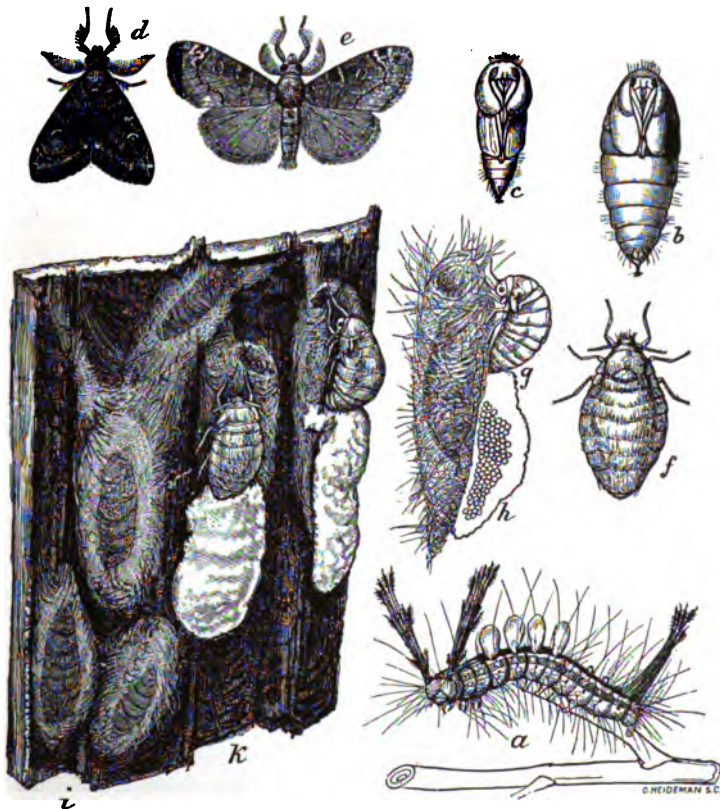


Fig. 10. *Orgyia leucostigma*: a, larva; b, female pupa; c, male pupa; d, e, male moth; f, female moth; g, same ovipositing; h, egg mass; i, male cocoons; k, female cocoons, with moths carrying eggs—all slightly enlarged (original).

striking in appearance. The head and two little spots on joints nine and ten are bright vermillion red; the back is velvety and there are three bright yellow lateral lines, and the whole body is thinly

clothed in long, pale yellow hairs, originating from wart like elevations. Toward the end of June they become full grown and begin to spin cocoons in all sorts of convenient places. In this cocoon the larvae change to pupa and the adult moth emerges in about two weeks. The female never leaves the cocoon but lays her eggs upon it. From these eggs a second brood soon appears and the same life history is repeated, the adult of the second brood appearing about September. The eggs laid at this time remain on the trees during the winter. This insect can be kept in check with comparatively little trouble. The egg masses can be removed early in the winter, while they can easily be seen. The destruction of the eggs must be thorough in order to prove effectual. The eggs are, as a rule, deposited low down on the trunk, or upon the main limbs, so that they can be easily reached. They are attached to the old cocoons and can be removed either by hand or by scraping them off. This operation must be thorough, not an egg mass should be overlooked. Spraying against this insect is effectual and the method suggested against the elm leaf beetle may also be used against this insect. It is essential that the caterpillars of the first generation shall be killed, as the second and more destructive brood will thus be prevented. A good preventative is to band the trees by tying a broad, thick strip of raw cotton about the trunk with a stout string. The bands should be renewed occasionally as they become matted and spoiled by rainstorms. Bands of insect lime can also be used.

THE WOOD LEOPARD MOTH, OR IMPORTED ELM BORER.

(*Zeuzera pyrina*, L.)

The appearance of this moth, in the adult and larval states, is shown in Fig. 11. In some localities it is the most serious of tree pests, attacking the maple, elm, linden and several other varieties, and unless checked, causes the death of the tree. The moths make their appearance in early summer, and continue throughout the warm season. The eggs are laid by the female moth on the branches, probably just into the bark. As soon as the young larvae are hatched they bore at once into the wood, usually at the crotch of a small branch, and work downward. They gradually get into the larger branches, sometimes entirely girdling the stick they feed in. They feed in the wood for at least two years and rarely emerge from the burrow, except for the purpose of beginning their work elsewhere. They eventually change to pupae, and wriggle through the bark, soon after which the moths emerge. One of the best preventatives of these borers is to maintain the trees in a flourishing condition. The prompt removal and destruction of infected trees and limbs will do much to keep this pest under control, and in the event of a severe attack, is the only remedy. Trees infested toward the tip only, should

be cut back in winter, and the infested parts burned. The eggs are laid generally in June, and if the trees are sprayed during this period with a solution of soft soap and carbolic acid, it will greatly

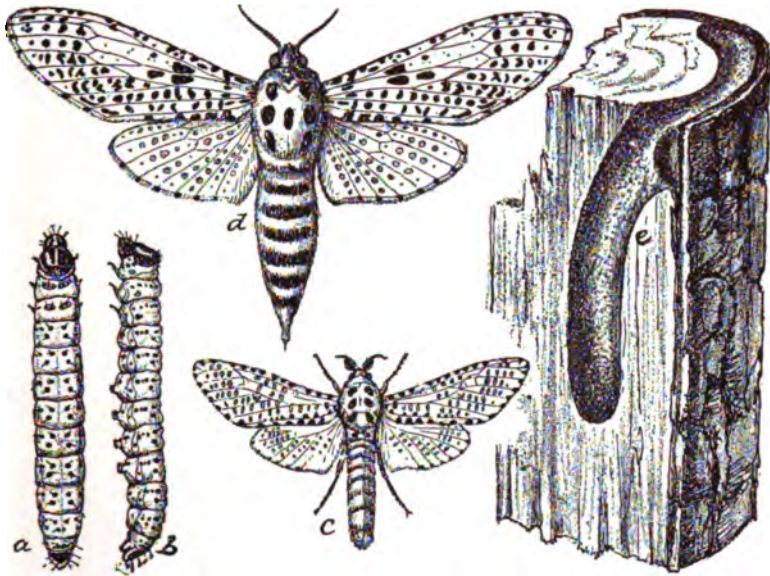


Fig. 11. The wood leopard moth: *a*, *b*, larva from above and from side; *c*, male moth; *d*, female moth; *e*, laval burrow. All natural size.

prevent further infestation. This solution can be applied as a spray, and should be renewed as often as washed off by rains, during the period of oviposition. Bisulphide of carbon can also be used to advantage in some instances where the infestation is not too bad. The tree should be carefully examined, and where a hole is found, bisulphide should be forced into it, and the opening sealed with putty or similar substance. This can be done either in winter or summer.

THE BAG-WORM.

(*Thyridopteryx ephemeraeformis*, Haw.)

Although this insect is not so destructive as some species of shade tree pests, it occasionally becomes formidable if not properly dealt with. It infests both coniferous and deciduous trees. During the winter the dependent bags may be seen hanging on the twigs of almost every kind of tree, and when found on the coniferous trees, are not infrequently taken for cones. These bags serve not only as a protection to the insect but to the eggs as well. If one is cut open it will be found to contain the shell of a chrysalis filled with many small yellow eggs (Fig. 12 d), surrounded by a delicate, fawn colored, silky down. In this condition the eggs remain from fall throughout the winter, until late in the spring when the larvae hatch, and at once

commence to construct a portable bag in which to live. Beneath these cases they feed upon the foliage, enlarging the little bags as the larvae develop, and during later life using small pieces of stems and twigs in their construction. When completed the bag is oval

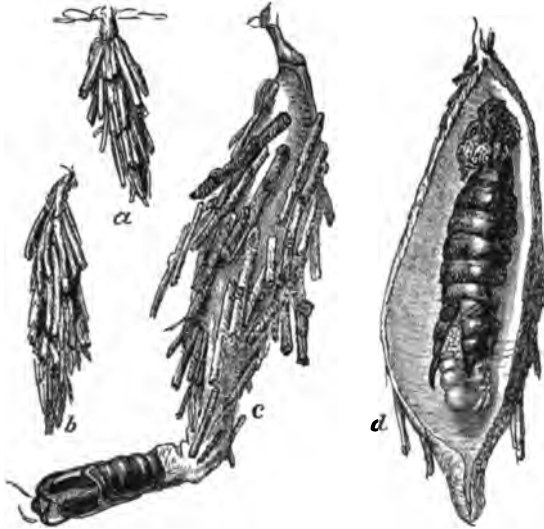


Fig. 12.—Bagworm at (a, b, c,) successive stages of growth. c, male bag; d, female bag—natural size (original).

in shape and somewhat elongated, being more or less irregular, on account of the material used in the construction. The silk itself is very tough and with difficulty pulled apart. The larvae are poor travelers during growth, and though they wander from one branch to another they rarely leave the tree upon which they were born, unless the tree becomes completely defoliated. When fully developed the larvae are very active, especially when numerous, and letting themselves down to the ground by means of a silken thread, travel a considerable distance until they reach another tree, which they ascend. On account of the protection afforded by its outside covering, the bag-worm is not attacked by any insectivorous bird or predaceous insect. In some latitudes is it attacked by parasites. The simplest remedy for this insect is that of spraying with London purple or Paris green. This is effective only in the spring, after the larvae are hatched. Effective work can also be done, according to Dr. Riley "during the winter time or when the trees are bare. The bags which contain the hibernating eggs, and which are easily detected then, may be gathered or pruned and burned. This work may be so easily done that there is no excuse for the increase of the species, where intelligent action is possible, the bags were better collected and heaped together in some open enclosure away from the trees, rather than burned. By this means most of the parasites

will in time escape, while the young bag-worms which will in time hatch, and which have feeble traveling power, must needs perish from inability to reach proper food."

(The various scale diseases of shade trees is not taken up in this report, but are treated separately in Bulletin No. 43, which will be mailed to any address upon request.)

REPORT OF THE FORESTRY COMMISSIONER.

Harrisburg, Pa., January 1, 1901.

Hon. John Hamilton, *Secretary of Agriculture*:

I have the honor herewith to present my report upon the work of the Forestry Division for the year 1900. It gives me great pleasure to say that the year has been one of substantial progress.

Under section 3, of the act of the 13th day of March, 1895, I find the statement made that the Secretary of Agriculture "shall have direct charge and control of the management of all forest lands belonging to the Commonwealth, subject to the provisions of law relative thereto."

When this act was passed the State had practically acquired no forest land. It commenced its purchases in the year 1898, in accordance with the act of the 30th day of March, 1897. There were purchased that year, at Treasurers' Sale, 52,429 acres and 98 perches. The equity of redemption upon this land did not expire until 1900. In the meanwhile there had been redeemed 36,107 acres and 8 perches, leaving unredeemed, and permanently in the hands of the Commonwealth, 16,322 acres and 90 perches. Of these lands, there are located in:

	Acres.	Perches.
Elk county,	1,980	
Lycoming county,	436	
Clearfield county,	353	
Clinton county,	8,317	91
Pike county,	5,235	159
Total,	16,322	90

By Commissioners' Sale:

Pike county,	4,175	54
Total lands belonging to State, purchased in 1898,	20,497	144

In addition to the above there were purchased during the year 1900, by the Commissioner of Forestry, with the consent of the Governor and Board of Property, under the act of the 28th day of April, 1899, the following lands:

	Acres.	Perches.
Cameron county,	4,760	
Tioga county,	990	
Lycoming county,	820	
Clearfield county,	10,196	149
Clinton county,	975	
Pike county,	2,339	76
	<hr/>	<hr/>
Total,	20,081	65
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All of the above lands, amounting to 40,579 acres and 49 perches, are already under existing law, "under the control and management of the Department of Agriculture, but assigned to the care of the Division of Forestry, as a part of a Forestry Reservation System."

It will be observed that the lands acquired and now by law under the control and management of the Department of Agriculture, may be conveniently grouped into:

- A. Those located in the central portion of the State, and,
- B. Those in the northeastern portion of the State.

Considering those of the first section, we may say that topographically they form a very complicated system of high land, being apparently in most instances what is left after very extensive erosion has done its work. For example, Keating appears by the railroad level to be just about seven hundred feet above tide. From there to the spring formerly known as Bear Wallow, but now known as Camp Liggett, on the head waters of the South West fork of Fish Dam run, a distance of about six miles, one rises abruptly twelve hundred feet. The water-shed between the Susquehanna river proper and the waters of Beech creek extends in the main in a northeasterly direction from Pine Glen for a distance of about twenty-five miles. Owing to the fact that the head waters of the streams on the opposite sides of this water-shed, occupying intervening spaces, extend beyond each other, or in other words, dove-tail into the territory each of the other, the actual dividing ridge is quite crooked and the topography correspondingly difficult for a stranger to understand. On the northern slope the descent from the dividing ridge to the main valley of the streams is very sudden; and this applies to the smallest as well as the largest tributaries. The consequence is that the streams flow through narrow valleys which might almost

be denominated gorges. On the southern side of this main axis the descent of the valley of Beech creek is more gradual; large basins occur and extensive swamps which are very suggestive of the work done by beavers in the earlier history of the country are found. From the declivities or slopes frequent springs break out, apparently draining the ridges or plateaus above which, as a consequence, are apt to be correspondingly dry.

Originally, the region now occupied by these reservations was very heavily timbered with hemlock, white pine and yellow or jack pine. Of this valuable timber scarcely anything remains except occasionally larger or smaller clumps of the yellow or jack pine. There is, however, in many places, still a fair growth (apt to be of small size) of chestnut and rock oak, with other less valuable kinds of timber.

I have thus described somewhat at length the important features of what is known officially as the Hopkins Reservation, because topographically it is a fair representation of all the lands which the State has acquired in that region.

The character of the country of course determines the uses to which it can be put. The altitude of much of the lands which we have been describing would of course render them unfit for the production of the crops which require the largest quantities of heat. Much of the surface too is rendered unfit for agriculture because of its rocky and steep character. The better portions of this ground are, without doubt, well adapted to grazing purposes. From what we now know of peach culture it is not improbable that there are here and there limited areas which could with advantage be devoted to peach trees. But apart from all this consideration the natural function of the whole region the State now owns is the production of timber.

It is eminently proper in this connection that one should look ahead a little, and anticipate a condition of affairs ultimately in this country, similar to that which now exists in the Black Forest or in the Spessart in Germany. We are accustomed in this country to regard a forest as usually having but few human residents, and from an American standpoint this has been, up to the present, correct. In Germany, however, and to a certain extent also in France and Switzerland, forests contain a considerable population, which not only derives its living from them but dwells within their limits. So, too, it will be in this country in the not distant future. When once our people are fully impressed with the idea that timber can be cultivated as a crop, and when examples of this are furnished, the citizens of the Commonwealth at large will be prepared to construct good roads and build homes and school houses within the limits of their reservations, and take every measure to protect

the growing timber and to economically cut it when it becomes mature. It is safe to predict that the time will come when there will be living in the State lands a prosperous, industrious and intelligent population of thousands of our citizens.

(B.) Reservations located in the northeastern portion of the State.

The northeastern State Reservation is almost wholly in Pike county, there being a very small body of land in the adjacent counties of Monroe, Lackawanna and Luzerne. In these regions there is an absence of the exceedingly abrupt character of country which distinguishes the central part of the State. There is of course an elevated part, but it is more in the nature of a plateau, having an elevation of about two thousand feet above tide. Then comes a regular descent to a lower bench, as in Porter township, in Pike county. The Hopkins Reservation is in a region of rapid mountain streams, with almost no lakes, except such as were first created by beaver dams. These are small and to a greater or less extent filled up. In the Pike County Reservation, on the other hand, while there are mountain streams there are also many large and beautiful lakes, which are mostly of glacial origin.

The timber on both reservations was originally much the same. There was probably more spruce and larch in the northeastern part of the State, though some of each species was also found in the central portion.

Public lands should of course belong to the public in the largest sense. We have elsewhere alluded to the fact that lawful hunting and fishing are allowed on State ground. It is proper that we should say that the State can not well make laws regulating these pastimes or vocations without recognizing these same laws on its own ground, where by common consent the game is also public property.

Quite apart, however, from what may be denominated the sporting relation of hunting and fishing there are other much more important considerations. If there is any one portion of the Commonwealth which should be vigorous in mind and body, thoroughly accustomed to the use of firearms, and specially fitted for the military service of the State, it is the men who most frequent these reservations. It will not be forgotten that the region from which the famous Buck Tail regiment came, to serve in the war of the Rebellion, was a lumbering region, and at that time no other portion of the State could have furnished such a regiment of riflemen.

In addition to this, however, there is a much more important relation of the public forests.

For years back the idea has been gradually gaining ground that there was a large class of diseases which required simply rest and suitable exercise in the open air, in the interest of the patient.

There is another class of diseases known collectively under the name of pulmonary complaints. One of which at least is now admitted to be contagious, or in some way transmissible from one person to another. Yet this very disease is the one, of all others, which is most likely to be cured by life in the open air, where it is certainly least likely also to be communicated by one person to another. The idea has gradually taken possession of the medical mind that old methods of treatment for pulmonary consumption must be abandoned; that the disease must be taken in its incipiency, and the patients isolated, as much as may be, in what are known as healthy regions. California, New Mexico, Arizona, Colorado, Minnesota, North Carolina, Florida and the Adirondacks, have all enjoyed a large share of public confidence and many of our own citizens annually seek one or the other of these regions for restoration of health. But as is well known there is a very large class of our population needing life in the open air, whose means render it absolutely impossible to reach or remain at either of the health resorts above mentioned.

It is therefore doubly important that it should be known that there are within the limits of our own State, and on lands which now belong to the Commonwealth, places which seem to possess almost, if not quite, all the advantages during the summer months which have been claimed for either of the most distant points. I feel, therefore, that it is a duty I owe to the citizens of this State that I should call attention to this fact, and furthermore, that I should pledge my own best efforts towards making such locations on the public lands available and accessible to those of our citizens who might be benefited by them.

It is hoped that the time is not far distant when in every quarter of the State there will exist a considerable-sized body of public woodland, and that the health officers and local medical organizations will lend their help (as the State Medical Society of Pennsylvania and the State Board of Health has already done), towards utilizing such forest reservations in the interest of public health.

Attention should be called also to the fact that under proper supervision and care utilization of the reservation as health resorts, will not in any way interfere with their value as sources of pure water supply for home purposes. Existing dangers then from this cause, instead of being greater than at present, will actually be very much less, because a strict guard against known dangers would be necessarily maintained.

Of the lands purchased in 1898, at Commissioners' Sale, the State came into immediate possession, and in view of the pressing problem of the future supply of pulp wood and railroad ties it was deemed advisable to begin at once an experimental plantation on a small

scale. Accordingly, three acres of ground were cleared, fenced and plowed. In the autumn of 1899, one thousand Carolina poplar cuttings were set out, and in the spring of 1900 five hundred more Carolina cuttings were planted. And along with them were one thousand Western Catalpas. The summer of 1900 was one of unusual drought, and tested severely the Carolina poplars, which were obliged to make roots and leaves, and the Catalpas, which reached us apparently almost dead. In order to avoid the direct rays of the sun, upon these young plants, the sprouts were allowed to grow over the plantation from the stumps remaining in the ground. The consequence was, that our young nursery was fairly well protected by shade, though it did present a most forlorn appearance, until in October, when the sprouts were removed and the ground again cultivated. It was then discovered that of the Carolina poplars set out in the autumn, a larger portion were alive and promising well than of those planted in the spring. Taking them altogether, about eighty per cent. of the fifteen hundred poplars were doing as well as could be expected. Strange to say, nearly all of the Catalpas revived and made a good growth.

This is the proper place to call attention to the fact that the ground selected, designedly, was of a poor character. We wished to raise no false hopes as to what might be expected from culture of these species on the abandoned ground of the Commonwealth. The Western Catalpa was planted solely in deference to public opinion. The chief claim made for it is that its lasting qualities when exposed to the soil, and its rapid growth, will soon make it available in future for railroad ties. I am in the highest degree sceptical upon this point, because I believe the wood is of too light a structure to endure the crushing weight of heavy trains, though I believe it will make good fence posts. We regard the experiment, however, so far as the growth of the plants are concerned, as highly satisfactory, under all the circumstances. Exclusive of the cost of the land, which was merely nominal, the entire cost of the plantation to-day has been one hundred and nineteen dollars and twenty-five cents (\$119.25).

In this connection it may be of interest to note that in several places over the State the actual work of forest restoration has been commenced. General Paul A. Oliver, of Oliver's Mills, Luzerne county, has already planted seventy thousand young white pines, which he reports as being in a flourishing condition. He has just informed me that he contemplates setting out sixty thousand more.

I regret to report that the forest fires of this year have been of unusual severity. The causes of it, however, are not difficult to discover. When the month of May opened, the State of Pennsylvania seems to have received for the month of April only about forty-five

per cent. of the expected rain fall. The woods were then in an extremely dry condition. Add to this the fact that the spring of 1900 was also remarkable for the number of days in which there were high winds. Thus there were present the conditions most likely to lead to disastrous results if the fires were once started.

The year 1899 it was discovered that out of sixty-eight fires, forty-seven of them arose from carelessness in burning brush. All the other causes combined so far as reported to us, produced but twenty-one fires.

The statistics for the year 1900 are not yet available, but, so far as I can see, they fully confirm the statements made of the previous year.

There has been a constant disposition to refer the largest number of fires in the State to the carelessness of railroaders. The statistics in our office do not bear out this conclusion. In some instances where the fires arose from burning brush it was on the part of saw mill men. But, by far the largest number of cases of which we have explicit statements arose through farmers allowing the fire to escape from the clearings which they were burning over. As the farmers are themselves the largest sufferers from these fires, it is in the highest degree important that their attention should be called to the fact that they are the ones to enter the most earnest protests against such carelessness.

In addition to the above, there have already been purchased by the Forestry Commission, created under the act of the 25th day of May, 1897, the following lands: in

	Acres.	Perches.
Centre county,	12,483	28
Clearfield county,	3,928	42
Clinton county,	25,735	80
Pike county,	15,675	122
	<hr/>	<hr/>
Total by act of May 25, 1897,	57,822	112
	<hr/>	<hr/>

The grand total of land now in actual possession of the State, by virtue of all of the above acts, is 98,402 acres and 1 perch.

Before any methods of forest restoration by tree planting commence, it is of the first importance that measures be taken to end or at least reduce the destructive agencies which have hitherto been at work. For example, it is well known, though most unwillingly admitted in certain quarters, that the browsing of cattle has been a most serious detriment to young growing forests. The annual nipping off of the terminal bud of small saplings can hardly fail to diminish the value and the quality of the timber produced on ground where this is allowed.

There is no doubt that a prohibition against cattle running at large on the State reservations must be enforced, though it doubtless will be very unpopular in the neighborhood where it is done. So long as cattle are allowed to run at large in any wooded region there is a strong temptation for persons, in whom the sense of moral responsibility is not very acute, to create forest fires, to burn away the underbrush and thus to increase the quantity of pasture for their cattle. It is not too much to say that this has been done frequently within recent years within this State. It would be hard to over-estimate the actual money loss to the Commonwealth which has resulted from this practice. It can not be too strongly condemned or too soon ended, and those who are charged with the duty of suppressing these evils should receive the strongest support from the Commonwealth.

We are too apt to ask what it will cost to suppress crimes of this kind and to forget the fact that the State exists for the suppression of crime regardless of cost, when this is necessary to protect its citizens and itself. It would be specially unfortunate to continue the practice of allowing cattle to range through young timber, especially if this be black oak, rock oak or chestnut, because there is no doubt that the next few years will witness such a demand for young timber of these kinds as has never existed before in this country.

Taking the State at large I have never known a time when during this month the danger from forest fires appeared more imminent than now. It is true between this and the month of April heavy falls of snow or rain may greatly diminish the danger. But at present there are large areas where there are more streams and springs wholly dried up and where the ground itself is drier probably than it has been within the lifetime of a generation. The ground burned over last year will not be likely to be so seriously injured this season.

On the other hand, the number of convictions obtained for creating forest fires last spring will no doubt have a certain effect in diminishing the number this coming spring. And there will be less excuse than ever before for failure of the county officers to do their duty in punishing those who create fires, because they have been shown that it can be done.

It is entirely safe to say that there has been a larger number of convictions this year, of those who have started forest fires, than ever before. Hitherto guilty parties have escaped punishment because it was supposed they could only be tried by civil suit and were responsible simply for damages. If they had no property, of course nothing could be collected, and this fact has deterred many persons from commencing suit who otherwise would have done so. The act approved June 1, 1887, as amended May 14, 1891, makes the defend-

ant liable for a sum not exceeding one hundred dollars, or an imprisonment not exceeding one hundred days. The case is one of criminal character, and therefore suit can be brought by any one before any magistrate in the county where the fires occurred.

I am forced, however, to admit that owing to the extreme reluctance on the part of county officers, or of those who have suffered from these fires, that it was deemed necessary that you should be obliged to exercise through your Commissioner of Forestry that part of your official authority which was conferred upon you by the act creating the Department of Agriculture, namely, "To make and carry out rules and regulations for the enforcement of all laws designed to protect forests from fires and from all illegal depredations and destruction, and to report the same annually to the Governor."

I would therefore say that Mr. Alfred P. Reid, of West Chester, has been engaged to take charge of such cases as have been reported to us and which there was but slight hope we could induce the county commissioners to push to a successful issue. Mr. Reid's success in his work has already made it clear that the county commissioners can protect the citizens of the county against these fires, if they will make a serious effort to do so.

As the law now stands the Commonwealth undertakes to pay half of the costs of detectives appointed by the county commissioners to ferret out and bring to punishment those who create forest fires, within the limits of their respective counties. I would suggest that the law be so amended as to oblige the magistrate before whom the case is tried, and conviction secured, to return to and collect from the county commissioners the entire cost of the apprehension and trial of a prisoner, where failure of the county detectives to do their duty has made it necessary for the Department of Agriculture to employ a detective to work out the case. It is unfair that the State should be obliged to pay twice for protecting the citizens of any county in cases where the commissioners have failed to do their duty.

There is one evil which is too serious to be overlooked, and which has been allowed to exist until it would be extremely difficult to deal with. I mean the custom of back-firing. In a limited number of cases it may, and doubtless does, accomplish good results. But in by far the greater number, it has worked untold harm. The evils growing out of this custom were more marked and more serious during the past season than I ever remember to have known them. Without waiting for a fire to be in an immediate neighborhood of their own property, land owners have commenced to back-fire whilst the original conflagration was yet miles away, and thus destroyed all the intervening timber. If the constables had promptly brought those men to fight the fire when the danger existed they would have rendered some service; as it was, they simply added to the destruc-

tion. One instance can be pointed out where during the last spring one neighbor after another began back-firing until the whole mountain side was a sheet of flame and miles of valuable timber destroyed. This pernicious system merits condemnation and prompt stringent legislation to make an end of it.

I am very much gratified to be able to report that the public interest in certain portions of the State in favor of the reservations has taken the form of protecting the State land against these destructive forest fires. This was notably the case in Porter township, Pike county, during the past season. So far as I am aware not an acre of ground belonging to the State was burned in that township last spring, though the fires were raging in every direction. There is no doubt whatever, that allowing lawful hunting and fishing on the reservations in that region was the effective cause of the favorable public sentiment.

On the land belonging to the State of Pennsylvania the sooner the system of fire wardens or rangers is established the better. The more promptly depredators of all kinds on State grounds are punished the better, because the earliest illegal deeds will doubtless be of trivial character; an attempt, as it were, to test the State. It is wiser that the offenders should be punished for such transgressions than that they should be encouraged to more serious offenses which, necessarily upon conviction, would lead to severer punishments to the criminal and heavier losses to the State. Probably public opinion is not yet ready for it but it would be a true economy to open fire lanes wherever needed on and through our reservations, and to connect the heads of streams by such lanes, which should be of sufficient width to render the escape of fire easy to prevent there.

The practice that hunters have of starting fires to keep themselves warm while standing on a deer run-way should be absolutely forbidden on State grounds. I would earnestly recommend that at the usual camping grounds a space should be cleared and burned over spring and fall so that whilst occupying these grounds camping parties would have no excuse whatever for allowing fires to escape.

There is no fund available for placing posters, with the penalties for creating forest fires, on the land of private citizens. I would recommend, however, that such posters should be conspicuously placed on all State lands.

Experience seems to prove, unfortunately, that there are cases where county officers elected by the people to care for and protect their interests utterly fail to do so, so far as forest fires are concerned. These same officers either wholly neglect to appoint persons to bring to punishment those who create these forest fires, or

appoint such inefficient detectives as to bring the law into contempt. I would therefore suggest that a bill be introduced at the coming session of the Legislature, as follows:

AN ACT

"For the better protection of timber lands against fire and providing for the expenses of the same, and directing what shall be done with the fines collected and costs paid.

Section 1. Be it enacted by the Senate and House of Representatives of the Commonwealth of Pennsylvania in General Assembly met, and it is hereby enacted by the authority of the same, That when the commissioners of any county or counties fail to appoint persons under oath whose duty it shall be to ferret out and bring to punishment all persons or corporations who either wilfully or otherwise cause the burning of timber lands within their respective counties, as is provided for by the act of July 15, 1897, or when they have appointed inefficient persons to do the work aforesaid, the Commissioner of Forestry may on the request of residents of a county in which such fires have been created, or on request of the owner or owners of land which has been injured by fires so created, appoint a detective or detectives and employ an attorney or attorneys to ferret out and bring to punishment as aforesaid those who cause the burning of timber lands, and all expenses incurred by the Commissioner of Forestry under the operation of this act shall be paid by the State Treasurer on warrant drawn by the Auditor General, if the said bills shall be approved by the Governor and the Commissioner of Forestry, and all the fines collected under this act shall be paid by the magistrate or by order of the court to the Commissioner of Forestry and be paid by him to the Treasurer of the Commonwealth.

"Section 2. When conviction is obtained under the provisions of this act of persons or corporations causing the burning of timber lands, then the Auditor General, on the request of the Commissioner of Forestry, may refuse to pay the State's share of the money due to the county for the services of the person or persons appointed by the county commissioners to ferret out and bring to punishment those who caused forest fires in the districts where such persons served as fire detectives, to make arrests and secure convictions, and for which convictions was obtained by the detectives appointed by the Commissioner of Forestry."

It is a perfectly well known fact that no other class of property has so little protection accorded to it in Pennsylvania as the unseated lands. There are regions where citizens, who are law-abiding in every other respect, deem it no crime or wrong to invade lands

which do not belong to them, and remove, without the owner's permission, such timber as they may desire. This whole system of theft is wrong, and should be ended as speedily as possible. The State, like every wise land owner, should see to it that an efficient guard to protect its property is promptly established. And I would respectfully call your attention to the necessity for providing means whereby all depredators upon the public domain may be promptly brought to justice.

Each year seems to develop some new enemy to our forests. Within the last two years, the insect known as the Walking Stick or Devil's Darning Needle (*Diapheromera femorata*) has been making more serious ravages in our forest foliage than were ever known before. In Columbia county, the trees on several square miles of mountain land were denuded of their leaves during the past summer. We commend this subject to the consideration of the entomologist of the State. It appears unlikely that these ravages may increase.

Nothing shows more how widely the forestry idea is spreading throughout the United States, than the number of laws which are being framed, or have been framed, in the various States, to induce the individual land owner to protect his standing timber and to increase its quantity. I include herewith the copy of a bill drafted for this purpose in the State of Indiana:

"Section 1. Be it enacted by the General Assembly of the State of Indiana, That upon any tract of land in the State of Indiana, there may be selected by the owner or owners, as a permanent forest reservation, a portion not to exceed one-eighth of the total area of said tract, which shall be appraised for taxation at one dollar per acre.

"Section 2. If such selection is an original forest, containing not less than 170 trees on each acre, it shall become subject to this act upon filing with the auditor of the county in which it is situated, a description of such selection as is hereinafter provided.

"Section 3. If any land owner shall plant not less than 170 trees on each acre of selected forest reservation, and shall cultivate and maintain the same for three years, then it shall become subject to this act, as herein provided.

"Section 4. Upon any tract selected as a forest reservation which contains 100 or more original forest trees on each acre, the owner may plant a sufficient number of forest trees which shall make up the required 170 trees per acre, when the sum shall become subject to this act, as in section 3.

"Section 5. No land owner shall receive the benefit of this act who shall permit cattle, horses, sheep, hogs or goats to pasture upon such reservation until said trees are four inches in diameter.

"Section 6. Whenever any tree or trees shall be removed or die the owner in order to avail himself of this act shall plant other trees in place of such trees as may be removed or die, and protect said trees until they are four inches in diameter, which shall at all times maintain the full number required by this act.

"Section 7. Not more than the one-fifth of the full number of trees in any forest reservation shall be removed in any one year, excepting such trees as may die naturally may be removed, when other trees shall be planted.

"Section 8. Ash, maple, pine, oak, hickory, basswood, elm, black locust, honey locust, Kentucky coffee tree, chestnut, walnut, butter-nut, larch, tulip tree, mulberry, osage orange, sassafras and Catalpa. shall be considered forest trees with the meaning of this act.

"Section 9. It shall be the duty of the auditor in every county to keep a record of all forest reservations as the same shall be filed with him, and he shall require the owner or agent to subscribe under oath the extent and description of the land reserved, and that the number of trees is as required by this act, and that he will maintain the same according to the intent of this enactment.

"Section 10. It shall be the duty of the assessor to personally examine the various forest reservations when the real estate is appraised, and to note upon his return the condition of the trees, in order that the intent of this act may be complied with. And if the reservation is properly planted and continuously cared for, he shall appraise the same at one dollar per acre."

In contrast with the above bill we find a most comprehensive measure has been introduced into the General Assembly in the State of Michigan for the creation of State Forestry Reservations. We quote the title here in order that the comprehensive character of the proposed law may be appreciated by the people:

A BILL.

"To withdraw from entry and sale and to set apart certain delinquent State tax lands in a part of the southern peninsula as State forest reserve lands, and declaring the same to be non-taxable; to define and establish the authority, powers and duties of the Michigan Forestry Commission over and in relation thereto, and to provide for the appointment and compensation, and to define the duties and powers of officials to carry into execution the laws relating thereto; to provide, by a statute of limitations, for perfecting the title of the State in and to the State forest reserve lands as against any defects or irregularities in the proceedings through which the State asserts its title; to preserve and protect the State forest re-

serve lands from trespasses and other wrongful act, and to that end, declaring certain acts to be misdemeanors and prescribing the punishment therefor and the manner of enforcing the same, and also prescribing the jurisdiction of courts and modes of proceeding in criminal and civil proceedings arising under this act, and defining the scope and extent of the power and authority of the Forestry Commission and of the officials aforesaid and other State, county and township officials in relation thereto, and providing punishment for neglect of such duties; and to provide an appropriation of money for the purpose aforesaid and for the necessary expenses of the Michigan Forestry Commission, and prescribing the manner of payment thereof, and to repeal all laws and parts of laws in conflict herewith."

It will be apparent to those who have studied the development of the forestry idea in Pennsylvania that the friends of the movement in Michigan have reached substantially the same conclusions that we have here. This is clearly indicated by the following extracts from their bill. Thus:

"It shall be the duty of the Michigan Forestry Commission to investigate and determine what part or portions of the lands aforesaid it will be for the best interest of the State and the public to retain and devote to the purposes of forestry, having regard not only to the soil and the natural characteristics and condition of said lands and their relative fitness for cultivation or for forestry, but also to the location of the various descriptions of such lands with respect to each other, as determining where forest reserves can be established so that the State's holdings shall be compact and contiguous or so nearly so as to render practicable and desirable the establishment and maintenance of forest reserves embracing the same; and having regard also to the location of such lands with respect to the sources of rivers and streams, and the protection and conservation of the moisture and water supply of the State, and such other natural conditions as may be deemed to have an important bearing upon the matter to be determined aforesaid."

"All lands hereby designated as State forest reserve lands, and such as shall hereafter be acquired as such, shall, from and after the expiration of the time limited by section four for perfecting title thereto, where the same are acquired on tax title, and from and after the vesting of title in the State, where the title is otherwise acquired, be non-taxable, and no assessment thereon shall be made, and if made the same shall be null and void as an assessment."

"The lands above designated as State forest reserve lands shall not be subject to private entry or to sale under any law now in force, or that shall hereafter be enacted, unless such law shall expressly be made applicable thereto. The possession, care, control and man-

agement, on behalf of the State, of the State forest reserve land is hereby conferred on and vested in the Michigan Forestry Commission."

"The Michigan Forestry Commission shall have power to cut, remove and sell (or to sell to any person with power to cut and remove upon such terms and under such conditions and restrictions as it shall deem advisable), any trees, timber, or other forest product on, or derived from, the State forest reserve lands; and shall have power to settle with any person for any trespass or other wrong of injury to the same. Provided, That no settlement shall be made in any case for amount less than such amount as the State would be entitled to recover under section fifteen in a civil action for the trespass in question if provided by the defendant to be not wilful. All moneys received by or payable to the Forestry Commission, from settlement for injury to the State forest reserve lands, from revenues arising from such lands, or from any other source (except costs, fines and penalties arising in any suit for judicial proceeding), shall be paid to the State Treasurer, who shall receipt therefor to the Forestry Commission."

"The Forestry Commission shall investigate modern forestry methods of caring for and dealing with forest lands, including the prevention and suppression of trespasses and forest fires, and investigate the most economical and feasible methods of promoting the growth of new forest on waste and cut-over lands; and make reports to each Legislature concerning its duties, the work accomplished, and such other subjects as it shall deem proper, and cause copies, not to exceed two thousand five hundred of each report, to be distributed for information and instruction of the public. Copies of such reports as aforesaid and ten thousand copies of this act shall be printed and bound in form for distribution and furnished to the Forestry Commission for that purpose by the Board of State Auditors."

"Process in criminal cases under this act shall be subject to the same provisions as govern process and its execution and return in other criminal cases for the prosecution of misdemeanors: Provided, however, That the Chief Forest Warden and his deputies shall have the same power as the sheriff of the county to serve, execute and return the same, and to arrest offenders, and to require aid and assistance in so doing. Arrests may be made without warrant, on Sunday, or any week day, by the sheriff or any constable of the county, or by the Chief Fire Warden or his deputies, of any person caught in the act of violating any provision of sub-division a or b of section 8 of this act; and thereupon such steps or proceedings shall be had or taken as are prescribed in like cases by section 4 of the act entitled 'An act to provide for the appointment of a Game and Fish Warden, and to prescribe his powers and duties.'"

"It shall be the duty of all prosecuting attorneys, sheriffs, under sheriffs, and deputy sheriffs, and of the constables and supervisors of the several townships in or adjoining which State forest reserve lands are located, to cause to be prosecuted, or to give to the chief deputy forest warden of the district, notice of, any violation of this act known to them, or which they have reasonable ground for believing has been committed within the county, or any county adjoining; and any failure to do so shall be and constitute a misdemeanor in office; and in addition to any other punishment therefor to which such officer is by law made liable, such officer shall forfeit his office and be removed therefrom by the Governor."

Minnesota and Wisconsin are also actively working out plans for forest restoration.

It must be allowed that an agitation so general among the most progressive States can only mean that there is a clear recognition of the need of a great reformation in our manner of dealing with forest wealth. Such a feeling is neither a fad nor a transient delusion. It is a part of the best thoughts of this practical age and has come to stay. Our great care should be to direct it wisely.

The question has been raised by a no less distinguished authority than Sir Dietrich Brandis, whether or not it is a wise policy to make the Commissioner of Forestry in any way responsible for care or help in the matter of private lands. Sir Dietrich is inclined to think that as a public officer the Commissioner will have enough to do to care for public lands.

As an abstract proposition his conclusion is no doubt entirely correct, and the time may come when his belief can be accepted here as a rule of practice; but for the present, the still struggling forestry sentiment requires all the help and direction it can obtain from the public officer.

It is fortunately true that in almost every portion of the State Forestry Reservations there is a marked tendency to the spontaneous restoration of timber. Occasionally a circumscribed area exists where this does not appear to be the case. It would be well worth while as the commencement of actual restorative measures to establish near these points small nurseries where at a minimum of expense for labor and transportation young trees could be produced to plant on such grounds as require them, if there was sufficient soil there to render their growth possible. This is a well known method of procedure in the German forests.

There is every reason why the State Forestry reservations should be made a source of revenue to the Commonwealth at the earliest possible hour. That they can be so made admits of no doubt whatever and that this revenue can be made perpetual, lasting from one

generation to another, is equally sure. The example of every country where forestry has been practiced as a scientific art is too clear to leave any doubt whatever upon this subject. If we recur again to the German forests we find that there has been a net revenue annually from each acre of the lands devoted to timber ranging from one dollar up to ten; and it is confidently expected that this revenue will be sustained from one year to another.

We can hardly suppose that for the present so large a revenue could be derived from our forests, because we have not yet been driven to the economy in the use of timber which prevails in Germany, or in other European countries. The fact, however, that we have still timber to burn (and are burning it accordingly) will soon bring its legitimate result, in the shape of higher prices because of increasing scarcity.

It would be a wise economy, I am led to think, on the part of the Commonwealth if at least one considerable sized area belonging to the State should be surveyed, the quantity of timber growing upon it estimated and the annual increment determined so that a rate of cutting could be decided upon at once. It is to be understood, however, that the annual cutting should not exceed the annual increase according to present rates of growth and that this rate of production is to be increased as rapidly as possible, upon the same ground, by the new growth coming on. It is exactly this which constitutes the difference between lumbering and forestry. The lumberman cuts upon the idea that there will be no restoration of timber after he is done. The forester cuts on the supposition that his crop is to be a perpetual one and that the rate of cutting shall not exceed the rate of growth.

If the State lands are ever to be made a financial success, as we believe they will be, it must be by the forester's method. It would be wise, therefore, in my judgment, to make a modest commencement at once of scientific forestry, upon the State lands already acquired, and trust to the results obtained to develop a public sentiment in favor of these operations. It would be in the highest degree unwise, either to fail to take the proper measures to produce this sentiment, or to go very much in advance of it.

There is still another reason why this work should be commenced, namely, to act as an object lesson which would encourage private citizens to follow the example furnished by the State.

In this connection it may be well to add, that when one considers how cheaply forest seedlings may be produced by the thousands, and the vast good that might be accomplished by gratuitous distribution of the surplus from the nurseries above alluded to, it would seem to be a judicious thing to make these nurseries distributing centres of young trees for our people; the cost would be merely nominal and the good gained would be substantial and real.

There is one lesson connected with forestry, which we have yet wholly failed as a people to comprehend. Forestry includes lumbering and there can be no forestry without lumbering. At every stage of growth from the period when the sapling may be cut for hoop poles up to the time when the mature tree is felled for construction purposes, thinning out is always going on. This is denominated improvement cutting. Or instead of this, the whole mature growth may be removed at one time after a new growth has either been started, or plans matured for doing so. In either case however, the forestry establishment of the State should include the machinery and force required not only for cutting but for sawing the timber where it would be to public advantage that it should be done.

I believe it would be safe, in view of the destructive methods at present in vogue, that the State should introduce on its own grounds improved methods of cutting and removing timber and that this should be done, as a rule by its own operatives, or at least under State supervision.

The lands purchased, thus far, by the Commonwealth have not only included the surface products but, in most instances, the minerals which lie beneath the surface. It can hardly be supposed that in the natural course of events all of this land should be without mineral value. Indeed there are already reasonable grounds for supposing that before long the State may be in possession of a revenue derived from mining operations within the limits of the Forestry Reservation. This is alluded to in order to impress the idea upon the public that there is no design whatever to withdraw from the market any product which may be contained on lands held by the State. The purpose is to obtain every possible utility, and all possible revenue from them, so far as this can be done without permanent injury to them.

I cannot forbear here even at the risk of reputation to call attention to the fact that Pennsylvania, as a State, is at present in great need of trained labor in our forests. It is unfortunately as true now as one year ago, that the land owner is unable to employ help that he can send into his woods and trust to do work which is so simple as thinning out judiciously the less from the more valuable wood where the former stands in the way of the latter; and it is unfortunately still true that there is no place in this State where such information can be had by those who would willingly avail themselves of the opportunities to gain it.

It would seem to require no argument that while the State of Pennsylvania is acquiring hundreds of thousands of acres of land upon which to produce the timber of the future, that among institutions of learning supported wholly or in part by the State some

should be found prepared to give this instruction. It is hardly to the discredit of the State College of this Commonwealth that it has not done more in this direction, for it has probably done all that could be expected of it with the means at its disposal and it is well known that it stands ready promptly to provide such instruction and make this instruction of practical and productive character whenever the means are furnished which will enable it to do so.

Mr. Conklin has been diligently engaged during the past year in the laborious task of collecting data concerning the timber cut of the year and the forest fires. It is safe to assert that the system which he has adopted is giving us conclusions which are in every way reliable and far in advance of those of earlier years.

It gives me great pleasure to add that the forestry work is becoming more popular constantly over the State.

This would appear to be a fitting occasion to thank you for the cordial co-operation and support you have always given me in my work as an officer of your Department, and to express the wish that the public may long have the benefit of your conscientious and efficient services.

I also desire to thank the other members of your Department, my colleagues, for much assistance which has always been cheerfully rendered.

I am, with great respect,
Your most obedient,

J. T. ROTHROCK,
Commissioner of Forestry.

Harrisburg, Pa., January 1, 1901.

Hon. J. T. Rothrock, *Commissioner of Forestry*:

Dear Sir: I have the honor to submit herewith statements concerning the extent of, and damage sustained by forest fires, and also the amount of timber cut in this State during the year 1899.*

Fires were very destructive by reason of the diminished rainfall over the State (it being 10.40 inches less than the normal fall), and also because of the question as to whether the act of March 30, 1897, making constables of townships ex-officio fire wardens, was constitutional. The Superior Court has said that the act is in full force, therefore we can hope for better results in the future because of the aid we should receive from the county officials.

*For Tabulated Statement, see Appendix.

Reports show that a great number of the fires were caused by persons carelessly burning brush on land that was cleared or about being cleared, and allowing the fire to escape them and run into the timber. Quite a number were attributed to hunters who start fires and then go off and leave them to burn over many acres of valuable timber.

The total number of acres burned over was 214,061, and the loss \$406,581; this is almost eight times the loss sustained in 1898. The county which had the greatest number of acres burned over was Centre, 26,688 acres being run over by fires, the most destructive fire being one started by persons carelessly burning brush. Six counties seem to have escaped fires entirely, or they were so small in extent that they failed to report them.

The cut of timber varied very slightly from the year 1898, a little more being cut. About the same number of acres were cut over, but there was a small increase in the number of acres that were cleared and will be used for agricultural purposes.

About 14,000,000 feet, board measure, more of pine were cut; about 39,000,000 feet more of hemlock, and 146,000,000 feet more of other woods. The amount of bark peeled, however, did not reach that peeled during the year previous by about 81,000 cords.

I am with great respect,

Yours truly,

ROBERT S. CONKLIN,

Clerk to Commissioner of Forestry.

REPORT OF THE STATE VETERINARIAN.

Harrisburg, December 31st, 1900.

Hon. John Hamilton, Secretary of Agriculture:

Sir: I have the honor to present the following report on the operations of the Veterinary Division of the Department of Agriculture for the year 1900, and shall incorporate with it a review of the work of the State Live Stock Sanitary Board for the same period.

The work falling within my province as State Veterinarian and Secretary of the State Live Stock Sanitary Board has continued to increase in volume and, I believe, in importance to the live stock industry and the public health.

The losses from disease among domestic animals have been distinctly less for the past year than for any previous year since the establishment of the Department of Agriculture.

Unfortunately, it is not possible to obtain complete statistics to show the precise extent to which contagious diseases prevail among farm animals for there is, as yet, no way to gether comprehensive reports on the causes of death among animals. It is necessary, therefore, to rely on reports from correspondents who are informed as to the health of farm animals. I have nearly 300 regular and as many more occasional correspondents who report on the prevalence of disease and the general health of animals and in this way have gathered reports that bear out the statement made above.

Such reports, and information gained by personal inspections in all sections of the State, show that tuberculosis is constantly decreasing in prevalence excepting in a few localities in some of the eastern counties. These reports and the reports on inspections and tuberculin tests on file in my office show a decrease in prevalence in infected herds to about 10 per cent., whereas the prevalence was fully 25 per cent. five years ago. Moreover, the percentage of infected herds has diminished considerably so that in the State at large there are now less than one-half as many tubercular cattle as was the case four years ago. It is also shown that there is less hog cholera, infectious abortion, black quarter and anthrax than for several years past.

The only disease shown to prevail more extensively than during the four or five years immediately preceding are glanders of horses

and contagious ophthalmia of cattle. The increased prevalence of glanders is directly due to the shipment of one car load of infected mules from East St. Louis, Ill., to the coal region of Eastern Pennsylvania. In this case glanders was carried to several collieries before the disease was discovered and the outbreak could not be suppressed before 35 mules had become infected. It is now fully under control and is believed to be completely eradicated. Still, a careful oversight is kept of the mules in the infected locality, so that if any latent cases exist they may be discovered before they have opportunity to spread infection widely. Aside from this outbreak due to imported animals, only 11 cases have been found in the State as compared with 9 last year and 13 in 1898. Pennsylvania is more free from glanders than any other eastern State and probably has as low a percentage of cases each year as the most favored State in the Union. In Massachusetts about 600 cases are found each year and nearly 300 cases have to be killed each year in New York city.

It would be very easy to re-infect the horses and mules of Pennsylvania with glanders were it not for the constant vigilance that is exercised to keep this and other diseases of animals in check.

A number of diseases of an obscure or indefinite character have been reported to the State Live Stock Sanitary Board by veterinarians or cattle owners and, when necessary, special investigations and laboratory examinations have been made to determine the nature of such diseases. In many instances such dangerous diseases have thus been recognized as anthrax, tuberculosis, rabies, glanders, actinomycosis, hog cholera and black quarter. In some instances the disease could not be positively diagnosed on account of defects in the material submitted for examination. To overcome this difficulty, some shipping boxes have been made for use in packing specimens for transport to the laboratory. These boxes are arranged to hold the specimen in a glass bottle encased in a metal cylinder to be surrounded by ice. Ten of these boxes have been distributed over the State and are now on deposit with veterinarians in different sections available for their own use in shipping specimens or for use of others in these sections.

But one disease has failed of identification during the year. This disease is one that prevails in the Spring and Summer among cattle in wild, mountainous regions. The disease is still under investigation and it is planned to make a special and very careful study of it when it recurs next year. It destroys several hundred cattle each year and is prevalent enough to make many thousand acres of land useless for pasturing purposes. A separate report will be issued upon this subject.

The accuracy of the general field work has been subjected to the most rigid laboratory tests at every step. Diagnoses, methods and results have thus been supervised and controlled, proven and meas-

ured. None of the work of the State Live Stock Sanitary Board has been carried on without the clearest light that the most accurate scientific methods afford.

The value of this part of the work is incalculable. Perhaps its importance will be evident when we recall that there is but one laboratory in the State where any attention is given to the diseases of animals and that is equipped and manned for this work. For the study of the diseases of man, every medical school (and there are seven in Pennsylvania) has one or more laboratories of bacteriology and pathology; every hospital is equipped with such a laboratory, and some of these are of the most perfect description; several municipal boards of health have such laboratories and a few private laboratories are maintained by physicians. So there is no lack of places where the diseases of man can be studied under the most favorable conditions, and the fact that so many laboratories of this sort are maintained at great expense shows that they are deemed important and necessary by those who support them. From this it should be evident that the laboratory of the State Live Stock Sanitary Board bears a most important and necessary relation to the general work of this Board and to the suppression of disease among animals throughout the State.

If, as is commonly admitted, the control of the diseases of animals is more perfect and less burdensome in Pennsylvania than in other States, I believe that it is due largely to the fact that the safety and accuracy of the work are guided and checked by the laboratory.

During the year the laboratory has made, under the direction of Dr. M. P. Ravenel, about 60,000 testing doses of tuberculin and all of the mallein and anthrax vaccine used by the Board. All of this represents a market value of about \$6,000.00.

As to the general field work that has come under my charge subject to your direction and to that of the State Live Stock Sanitary Board, I shall refer first to tuberculosis.

Tuberculosis.—This disease is the most prevalent, the most dangerous and the most destructive of all of the diseases of cattle in Pennsylvania. While the ravages of tuberculosis have been largely reduced, the disease still prevails to an alarming extent in some districts and continues to spread, although at a less rapid rate, and to destroy cattle and to contaminate their products. The fact that this disease has been repressed to such a great extent in some large districts and to a certain extent in almost all parts of the State furnishes the ground for a recommendation, which I do not hesitate to make, that the present plan for combatting it be continued in its essential features, but with a few modifications, demanded by awakened and more active public sentiment in favor of repression and by the development of knowledge of effective methods.

As has been remarked recently by Professor Osler: "The history of the acceptance of any great truth in medicine is an interesting study. A slow, gradual recognition seems necessary to permanency and stability." It is so with the main facts relating to tuberculosis.

It has been difficult for people to grasp the real significance of the discoveries and researches that have shown and conclusively demonstrated that tuberculosis is a contagious and, therefore, a preventable disease. It has been difficult for stockmen to realize that an animal that looks well may in fact contain extensive areas of tubercular tissue and be a distributor of germs of tuberculosis. It has been hard to bring cattle owners to an appreciation of the accuracy of the tuberculin test. It has required hundreds, yes thousands, of demonstrations in all parts of the State to spread knowledge of these facts and to impress the lessons that depend upon them. It has been necessary to carry out the work of inspection and to make post mortem examinations on tubercular animals with the fullest publicity permitted by the owners of the animals in order that the facts and the principals underlying the work the State has undertaken may be fully understood and appreciated. One result of teaching of this sort is shown by the large number of voluntary applications from herd owners in sections where inspections have been most public and most numerous. And, it should be noted, the applications are from the leading stock owners, the best informed and most progressive men and those who have studied the question most carefully. Is it not significant that the largest and best known herds in this State have been tested with tuberculin and that additions to such herds are bought subject to the tuberculin test; that nearly every Agricultural Experiment Station herd in the country has been tested and that the test is recommended by such stations, and that the largest and finest dairy herds in the United States, herds that produce the milk that is most highly prized in the markets of Boston, New York and Philadelphia, are all tested with tuberculin and are kept free from tuberculosis?

All of this shows that the facts are being appreciated and acted upon and that there exists a powerful movement toward ridding our dairy herds of this scourge.

The work of the State Live Stock Sanitary Board has been with this current of sentiment. No doubt it has accelerated the current somewhat by demonstrating the facts in regard to the disease and by bringing them to the attention of interested persons.

Where there has been reluctance to accept the assistance of this Board it has not been forced upon an unwilling cattle owner, he has been encouraged to live and learn and to profit by the experience of his neighbors. Indeed, at no time have the resources of the State Live Stock Sanitary Board been sufficient to meet the demands of

those who wished to voluntarily co-operate with the State in the repression of tuberculosis in individual herds. Inspections have been forced only in respect to cases of advanced, generalized or udder tuberculosis.

Work conducted on this basis has resulted in the repression of tuberculosis in many localities to such an extent that a number of veterinarians conducting large country practices and well informed stockmen have reported that they do not know of the existence of a single animal with tuberculosis in localities formerly extensively infected.

It should not be inferred that all of this work of repression has resulted directly from State effort, although it is no doubt true that most of it is at least the indirect result of such effort. Because the danger of keeping a tubercular cow in a herd is now more fully realized, because there is a potent public sentiment against keeping such cows about and selling their products and because, through attention to the subject, tuberculosis is now more quickly recognized in the living animal, tubercular cattle are not permitted to mingle with those that are healthy to the extent that they were and much danger is thus avoided.

While this tendency to quietly remove tubercular cattle is effecting the cleaning up of many herds it is also resulting in the infection of others that belong to less cautious men. There can be no doubt that many cattle are thrown on the market because they are tubercular and their owners are afraid to keep them. It is not believed that there is as much of this in this State as in some others that have no regulations on the subject of tuberculosis, or regulations that are less satisfactory to stock owners. (This subject will be referred to again below, in connection with the discussion of the inspection of cattle entering interstate trade.)

It is important to consider a remedy for this condition, a way to avoid danger from this source. The danger could be avoided almost wholly if it were possible for the State to pay the full market value for such animals. If the owner of a tubercular cow could sell her to the State for as much as he could get from a buyer who is not aware of her diseased condition, the State would no doubt be selected as a purchaser in almost every instance, because it would be most unreasonable for a seller to prefer to take the risk of having his reputation injured, the cow returned with a demand for the purchase price or of having to defend a suit for damages when he could obtain as much money with no risk. Since, however, it is not possible, under the law, to pay more than \$25.00 for an unregistered cow, more than the State allowance can sometimes be obtained from an unwary individual.

I believe that much of the danger from this source could be avoided if a law were enacted prohibiting the sale of animals suspected of being tubercular excepting with special permission from the State Live Stock Sanitary Board, or from an authorized agent of this Board; such permission to be granted only under the express condition that the animal should be kept in quarantine until shown to be free from tuberculosis or until killed in a slaughter house subject to competent and constant inspection.

The law and the regulations governing the inspection of cattle coming into Pennsylvania have received much attention during the past year. There are now 18 States that have a requirement similar to that existing in this State providing for the inspection and tuberculin test of dairy cows and cattle for breeding purposes coming in from other States. This means that tubercular animals of these classes are excluded from many States and they are, therefore, shipped in increasing numbers to other States not so protected.

Many cows from the west are tested at Buffalo. Those that are sound are shipped to States requiring certification to this effect and those that do not pass inspection are retained in New York or shipped to Connecticut. (Smith, Peters). Since this inspection has been in operation, buyers have ceased purchasing in some districts in New York, Maryland and Virginia where there is much tuberculosis and buy more in Ohio and in districts of the states above mentioned that are known to have healthy cattle. More cattle from western Pennsylvania are shipped to the eastern counties now than formerly and as such cattle come from breeding districts where tuberculosis is a rare disease the law is advantageous in this respect both to the sellers and the buyers of this State. In spite of the care that is exercised, about 2½ per cent. of the cattle inspected under this law are tubercular and are prevented from entering Pennsylvania herds. There can be no doubt that the percentage of tubercular animals entering would be much greater if buyers did not exercise the care that they do no account of the inspection their cattle must pass.

This law was enacted in response to a demand from herd owners for protection from outside contamination and because it was believed that such a regulation would help to make permanent the work of suppressing tuberculosis carried out by State authority.

At the time of the passage of this law many tubercular herds in other states were being broken up and disposed of by public and private sale and there was exceptional danger of contamination from this source. Such danger still exists.

On the whole, the law has worked smoothly and there is an appreciable market advantage in most places in selling cattle that are known to have been tested and proven to be free from tuberculosis. It has, however, been necessary to keep a constant oversight of ship-

ments to insure the enforcement of the law and two agents have been employed for a part of the year to assist in this work. Four successful prosecutions have been brought before justices of the peace against violators and, as these were first offenses, the minimum fine was imposed in each instance.

Since this law necessitates the expenditure of money on the part of the shippers, and this means somewhat increased cost to the purchasers, it seems appropriate to analyze the cost and gain.

The increased cost of inspected cows is equivalent to the cost of the inspection. This averages about 50 cents-per head. In order that all possible collateral expenses may be surely covered, the extreme figure of \$1.00 per head may be taken as the basis for this calculation. On 15,000 cows this means \$15,000.00 expense or cost of inspection. Now, what is the gain? Since $2\frac{1}{2}$ per cent. of the cows examined are tubercular and prevented from entering farmers herds, 375 cows are thus directly excluded. At the reasonable average of \$40 per head this means that \$15,000.00 worth of tubercular cows are denied sale in Pennsylvania. That is, the purchasers of cut-of State cows pay \$15,000 for the inspection, but save \$15,000 that they would otherwise expend for tubercular cows. But this is not the only saving. From two to three times as many tubercular cows would be brought into Pennsylvania and sold, were they not inspected, so that the direct saving may be safely estimated at \$30,000.00. Moreover, many of these tubercular cows would spread infection and some of them would start disease that would undoubtedly infect while herds. (As one of many examples: The Piollet herd was thus infected by a cow from New Jersey and 156 cattle became tubercular involving a loss of more than \$6,000 on this single herd.) If each cow should infect but an average of one animal the loss would be doubled and would reach \$60,000.00 per year. I believe that this estimate is most conservative and that the money spent in testing cows from other States is the means of saving, to cow owners, at the very lowest, four times as much in direct loss from tuberculosis.

The arrangements for making the inspections are such that there is no friction or interference with traffic excepting occasionally in the case of an uninformed shipper or one who is endeavoring to evade the law.

During the present calendar year 614 herds comprising 9,274 cattle have been tested with tuberculin. More than 10,000 have been examined physically. One thousand two hundred and twenty-seven cattle have been condemned as tubercular and appraised. The total of appraisement is \$28,339.50, or an average of \$23.10 per head.

Anthrax.—The use of anthrax vaccine has increased this year. Six hundred and ninety-five doses have been sent out from the labora-

tory and used in this State. This has been the means of keeping anthrax in check to a very large extent.

The great danger in connection with this disease is from infection with germs that have passed into the soil from the carcass of an animal that has died of anthrax. The disease does not ordinarily pass from a living diseased animal to a healthy animal. The transmission is indirect, through the soil. Hence, the most vital step in preventing anthrax is to prevent the infection of the soil. Such infection usually results from the scattering or the decomposition of the carcass of an animal dead of anthrax. The scattering of anthrax germs from this source can be prevented by burning the carcass or by burying it deeply in lime. However, if the soil is already infected there is no way to purify it and it is for several years dangerous to all animals that graze upon it unless they are protected by vaccination.

This protection not only safeguards the individual animals vaccinated but it also furnishes a large degree of general protection in the infected districts by preventing the occurrence of disease that would cause the soil to become further contaminated and enlarge the limits of the infected area. For this reason, vaccination is not looked upon as a matter of importance to the owner of the exposed cattle alone, but as a matter of importance to the public.

The same position has been taken in regard to vaccination to prevent black quarter. Hence vaccination to prevent these diseases has, where necessary, been carried out at State expense. The black quarter vaccine used has been obtained from Dr. D. E. Salmon, Chief of the Bureau of Animal Industry. Two hundred and forty-seven doses have been used.

The results of vaccination have been most successful. Protection has been afforded as attempted in almost every instance. So far as known only two animals have died of black quarter within six months after vaccination. None of the animals vaccinated against anthrax have died of anthrax excepting one cow which had received only the first portion of the vaccine and had not been fully immunized.

The reprehensible practice of allowing the carcasses of animals dead from natural causes to lie on the surface until decomposed and melted away or until distributed by buzzards or dogs still prevails in some localities. When animals die of certain infectious diseases, of which anthrax and black quarter are examples, this neglect of carcasses is excessively dangerous. Infection that could easily be confined to one farm is in this way spread widely and injures an entire community.

There is at present no way to require the proper disposition of the carcasses of animals dead of dangerous diseases if the owners of such animals neglect or refuse to attend to it. In some cases of this sort it has been necessary for the State Live Stock Sanitary Board to employ men to burn or bury carcasses.

Rabies has prevailed extensively during the year in some sections. There can be no doubt that the measures directed against this disease have not been as successful as they would have been had there been more authority to enforce a general quarantine of dogs in infected districts. At present, if a general quarantine of dogs is proclaimed in a certain district and dogs run at large in violation of the quarantine, there is no means to prevent such violation excepting to bring legal action against the owners of the dogs. If the dogs have no owners or the owners can not be found there is no way clearly prescribed for dealing with them.

Contagious Ophthalmia of cattle has prevailed very extensively in the southern and western parts of the State. This disease consists in a catarrhal inflammation of the eye lids usually accompanied by inflammation of the cornea and sometimes by a general ophthalmitis that results in blindness. To check the extension of the disease it is only necessary to isolate the healthy animals and disinfect. The curative measures that it is necessary to employ are comparatively simple. In every outbreak full instructions have been given for the prevention and cure of the disease.

Where outbreaks of this disease have not been reported and where treatment has been neglected the consequence have sometimes been serious.

Sheep Scab.—A few outbreaks of sheep scab have occurred and all were traced to direct importations of sheep from other states. In each instance the sheep were held in quarantine until they were cured. No cases of this disease are known to exist in Pennsylvania at this time.

Hog Cholera has, as usual, occurred in many parts of Pennsylvania but, altogether, fewer cases have developed than for many years past. This disease can almost always be traced to a direct importation of diseased swine from some southern or western State. The disease is not endemic in any part of Pennsylvania. This renders control much more successful than can be the case in permanently infected states. The plan of operation that has been adopted has been to inspect each infected herd, quarantine if necessary, isolate healthy hogs, disinfect and use the tonic treatment recommended by the Bureau of Animal Industry. The losses from hog cholera this year have not exceeded \$100,000.00 as against \$400,000.00 in 1897.

It is highly important that reports of this disease shall be rendered promptly, because it is easy to check the spread of hog cholera from the first herd in which it appears in a locality. This is usually composed of swine that have been exposed to infection in another State, in stock yards or on the cars. After disease has spread from such a centre to a number of surrounding farms the difficulty of suppressing the outbreak is vastly increased as is the expense of this work and the losses from the disease.

Abortion.—There was a time when it was held by some practical men that abortion caused as much loss in dairy herds as tuberculosis. If this was ever the case it is not so now. While the losses from tuberculosis have been considerably reduced, the losses from abortion have been reduced still more. This is due largely to the fact that the disease is now generally recognized as contagious and is handled in a way that is capable of checking the spread of a contagious disease. Some owners of dairy herds do not attempt to treat aborting cows but prepare them for slaughter and dispose of them to the butcher. In this way the progress of the disease can be checked, it is true, but with considerable loss.

Usually it is safe and much more economical to follow the plan recommended in a separate report from this office.

Forage Poisoning. (So-called cerebro-spinal meningitis).—This disease has for many years caused very great losses to horse and mule owners in Pennsylvania. It has been carefully estimated that single counties have some years lost \$100,000 worth of horses and mules from this disease alone.

Forage poisoning has gone under a great number of names such as putrid sore throat, cerebro-spinal meningitis, staggers, etc. The cause of this disease has not until recently been definitely ascertained, although it has been suspected for a long time that it was caused by certain impurities of the water or by decomposition of the food. Attempts to confirm this theory have always resulted negatively, and recently there has been a tendency to discard the old view and to ascribe the disease to other causes. This doubt as to the causes of the disease has retarded all preventive measures, because no one knew just what to avoid or what conditions to improve. It is notoriously difficult to fight an enemy in the dark. It is much easier to fight a foe that has been located and whose methods are understood.

There is some reason for congratulation, therefore, that the cause of an outbreak of this disease has been traced to a definite source and made clear.

Recently, in Delaware county, cerebro-spinal meningitis, so-called, appeared among the horses on a dairy farm and attacked seven, kept in a stable with cows. Of these, five died. Upon inspecting the

premises for the purpose of discovering, if possible, the cause of the disease it was found that a fresh silo had been opened and that there was a possibility that some of the silage had been fed to the horses, but only in quite small amounts.

Some of the silage was taken for experimental use and was fed to a horse. The horse contracted the same disease that had killed the horses on the dairy farm and died six days after the beginning of the experiment. A second and a third horse were killed in the same way. So, in this instance, it is clear that the silage was the cause of the disease.

Silage is often fed to horses in large amounts and for long periods without causing any injury. So all silage is not harmful, it is only decomposed silage that appears to be harmful. Nor is decomposed silage the only cause of this disease. The disease was prevalent before siloes were invented and occurs on farms and in stables where there is no silage. The observations thus far made indicate that any decomposed food is dangerous for horses and some decomposed foods may produce fatal effects. It is not necessary that the decomposition shall be shown by a change in consistency and an offensive odor—the usual signs of putrefaction. Sometimes, foods appear to be capable of causing this disease when the changes they have undergone are very slight, so far as can be determined by a superficial examination.

By consideration of the fact now definitely established that some decomposed food is capable of poisoning horses, we are in a far more favorable position to prevent such losses than ever before.

A Veterinarians' Institute.—It has been the policy of the State for years to encourage meetings of men engaged in any particular work that is of advantage to the entire public, so that knowledge of improved processes and methods may be disseminated, difficulties cleared up and irregularities and angularities of practice rubbed down by contact with those pursuing more efficient methods.

The teachers' institute and farmers' institute are instances in point. But the State also appreciates the value of and encourages meetings of the State Horticultural and Dairy Associations. It is recognized that this is an efficient and economical way of distributing needed information throughout the State. It makes a number of centers for the dissemination of knowledge in special lines. With a similar object in view, the State Board of Health arranges each year for a general conference of the men engaged in sanitary work throughout the State.

Heretofore, there has been no organized conference devoted especially to the study and discussion of matters pertaining to the suppression of the contagious diseases of animals. These subjects have had some consideration at the meetings of the State Veterinary Society, but the time devoted to them has necessarily been restricted to narrow limits.

It is to the advantage of the State that there shall be in all parts of it men who are informed as to the most accurate and reliable means to be employed to diagnose and prevent contagious diseases of animals. It is natural that such knowledge should be expected of the veterinarian. But in order to have it in available form and always up to date, the brightening, freshening, instructive influence of a conference with experts appears to be necessary. This applies with especial force to knowledge of the rarer diseases that are seen only at long intervals.

With the object of organizing the veterinary sanitary work of the State on a more uniform basis and for the purpose of bringing to the attention of veterinarians the newer developments of science in relation to the suppression of disease among animals, a general conference of veterinarians was held last February for one week under the auspices of the State Live Stock Sanitary Board at, and with the aid of the faculty of the Veterinary Department of the University of Pennsylvania. Nearly 100 veterinarians from all parts of the State attended the meetings, lectures and demonstrations and entered into the discussions.

The work done was considered so valuable by those who took part in it that resolution was unanimously adopted asking that it be repeated in 1901.

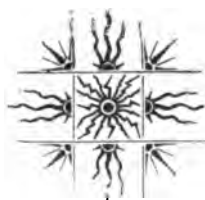
It is believed that in this way the State can be benefitted and at with little if any expense, for the instruction was given by volunteer lecturers and demonstrators and the equipment of the Veterinary School of the University was freely placed at the disposal of the conference.

The knowledge distributed in this way is special knowledge of public value for which the individual veterinarian receives little if any direct reward, as contrasted with the general knowledge that he must use in his every day practice and with which he earns his living.

Expenditures.—For the fiscal year ending May 31, 1900, the State Live Stock Sanitary Board was allowed \$40,000 for its general work of suppressing diseases of animals. This money was expended as follows: For tubercular cattle, \$27,238.50; for glandered horses, \$465; for inspecting tubercular herds, \$3,727.92; for inspections for the purpose of suppressing diseases other than tuberculosis, \$2,269.84; for expense of vaccinating against black leg and anthrax, for cremating carcasses, for miscellaneous expenses, including supplies and office help, \$4,814.36; for enforcing the inter-state cattle inspection law, \$1,483.74.

Respectfully submitted,

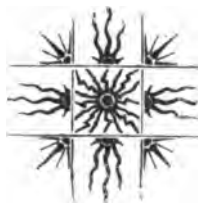
LEONARD PEARSON.



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REPORTS OF SPECIAL EXAMINATIONS AND INVESTIGATIONS.

Note.—The following investigation by Dr. Bergey was made in the summer season, when the conditions surrounding the cattle were not as varied as they are in winter. This no doubt accounts for the slight differences found in the bacteriological examinations between different herds.

AN INVESTIGATION ON THE VALUE OF CERTAIN SANITARY AND OTHER PRECAUTIONARY MEASURES, EMPLOYED IN THE PRODUCTION AND MARKETING OF MILK, UPON THE BACTERIAL CONTENTS OF THE MILK.

By D. H. BERGEY, M. D., *of the University of Pennsylvania.*

OUTLINE OF THE INVESTIGATION.

1. This investigation is to comprise bacterial counts made on milk derived from individual cows, and from dairies of different classes, to ascertain the number of bacteria in the milk of individual cows in different dairies, and of whole dairies belonging to the different classes with regard to the precautionary measures taken, the estimation of the prevalence of streptococci in the milk of cows in dairies of the different classes, and, incidentally, the presence of tubercle bacilli in the milk of certain cows may be determined.

Note.—By dairies of different classes is meant, first, those in which the utmost care is taken in the management of the dairy in all its details; second, dairies in which ordinary precautions are taken as regards the selection of the cows, the nature and variety of their food, care and cleanliness of the cows, milkers and milk utensils; third, dairies in which no particular care is observed in the selection and management of the cows, or in the collection, storing and marketing of the milk. Three or more dairies of each class should be studied with more or less detail.

2. The samples of milk to be examined are to be collected in person on the premises and stored in sterile bottles, packed in ice, and taken to the laboratory for examination as soon as possible. Such examination is to be made on the day of collection if it is possible to do so. If the samples are not examined the same day, they are to be packed in ice until the next morning, when the examination is to be made.

3. From each sample of milk so collected, duplicate gelatin plates are to be made with a definite volume of the sample of milk, and the bacteria developing in the plates are to be counted on four successive days in order to obtain the data for the numerical bacterial content of each sample of milk. The plate cultures are to be maintained at a uniform temperature of about 20 degrees C. (68 degrees F.).

4. Each sample of milk is to be centrifugalized and the sediment examined microscopically to determine the presence of streptococci and of pus cells in the milk, and the relative number of pus cells per field of the microscope, using the 1-12 inch oil immersion lens.

5. Samples of milk are also to be collected from milk cans on the depot platforms as they reach the city, in order to determine the bacteriological character of the milk.

6. In certain instances it may be advisable to examine the sediment, after centrifugalizing the milk, for the presence of tubercle bacilli.

7. The cultural and microscopic experiments are to be conducted in the Laboratory of Hygiene, University of Pennsylvania.

Large sums of money have recently been expended on improved methods of producing, storing and marketing of milk, and it was deemed advisable to ascertain the economic and hygienic value of these methods as shown in the bacterial content of milk taken at different stages in its course from the cow producing it to the consumer. A great deal of work has been done on the bacterial content of market milk, but as yet very little work has been done to determine the sources of bacteria in milk and the various stages at which they gain their entrance.

The researches of Archibald R. Ward (Bulletin 178, Cornell University Agricultural Experiment Station), have shown that (1) "Certain species of bacteria normally persist in particular quarters of the udder for considerable periods of time. (2) It is possible for bacteria to remain in the normal udder and not be rejected along with the milk." These statements are based on the results of numerous examinations of the "fore" milk as well as of the bacteriological study of the udders of nineteen cows immediately after death.

The research of Dr. William Royal Stokes (Annual Report of the Health Department, Baltimore, Md., 1898, and Medical News, July 10, 1897), indicated that the sanitary surroundings, as well as the nature of the food, influence the prevalence of pus cells in the milk of different herds. In cows kept in the country, in a well ventilated stable, with good, roomy stalls and good pasture, and fed on bran, ground corn, and hay, there was a general average of 1.1 pus cells to the microscopic field. In cows kept in the country in badly ventilated stables, narrow stalls and bad pasturage, and fed on distillery grains, cut hay, and bran, there was a general average of 11.3

pus cells to the microscopic field. In cows kept in the city, always confined to stables, with narrow stalls, no ventilation, light, or pasturage, and fed on brewery grain, distillery slops, bran and hay, there was a general average of 19.2 pus cells to the microscopic field.

Mr. M. O. Leighton, health inspector, Montclair, N. J., has reported on the bacterial contents of milk as produced and stored under varying sanitary conditions (Proceedings of the Twenty-fifth Annual Meeting of the New Jersey Sanitary Association, 1899). He found that the numerical bacterial content of the milk was a reliable indicator of the degree of care and cleanliness observed in the collection and storing of the milk. All the milk examined was bottled at the dairies and was usually examined from 12 to 18 hours after milking. In many cases, however, the milk was 24 to 36 hours old when examined. In the best dairies the results ranged from 2,366 to 8,000 bacteria per cubic centimeter of milk. The milk from these dairies is collected in sterilized vessels and all the modern improvements in the collection and storing of milk are employed. In the worst dairies the results ranged from 5,000 bacteria per cubic centimeter up to uncountable numbers.

Dr. G. Leslie Eastes, in a paper on the pathology of milk (British Medical Journal, November 11, 1899), states that in normal milk there is always a slight leucocytosis. The leucocytosis is frequently associated with so-called "mucous" threads. In hardly any case are these mucous threads present unaccompanied by pus cells, and the presence of such threads may usually be taken as corroborative proof that the leucocytosis is due to some inflammatory lesion of the ducts of the udder. "Of 124 samples in which an excess of leucocytes amounting to pus was found, however, 47 were unaccompanied by this mucin-like material. In such cases there is, however, another indication of the nature of the leucocytosis, and this is the presence of streptococci. Not that streptococci cannot be found in normal milk. By cultivation it is possible to prove that some samples of otherwise normal milk do contain the streptococcus, but in normal milk its presence is the exception, and, when present, in but very small numbers. When pus is present, however, it is far otherwise, so far as the streptococcus is concerned; there is no need to proceed to cultivation." Of 186 samples of milk examined, 47 contained pus, and muco-pus was present in 77 additional samples. Streptococci were found in 106 samples, absent in 53, and undetermined in 27, or 30 per cent. contained pus, and 48.7 per cent. muco-pus, or 78.7 per cent. of all mixed milks examined. Streptococci were found in 75.2 per cent. of the samples, absent in 15 per cent., and undetermined in the remaining 9.8 per cent.

Dr. Max Beck (Deutsche Vierteljahrsschrift für öffentliche Gesundheitspflege, Bd. XXXII, s. 430, 1900), reports on the examina-

tion of 56 samples of Berlin market milk. The milk was collected in milk stores and from milk wagons, in sterile vessels, and taken to the laboratory. Definite portions of each sample were injected intraperitoneally into guinea pigs in order to ascertain whether tubercle bacilli or other pathogenic organisms were present. By this means he found tubercle bacilli in 17 samples, or 30.3 per cent. Streptococci were found in 34 samples, or 62.3 per cent. These streptococci produced purulent peritonitis, causing the death of the animal in three or four days. Mice inoculated with a small amount of a pure culture of the streptococci, either subcutaneously or intraperitoneally, succumbed in 24 hours from general infection. Guinea pigs inoculated intraperitoneally with 0.1 to 0.2 cubic centimeter of a bouillon culture of the streptococci died in 2 or 3 days, and post-mortem examination revealed the streptococci in the blood and organs in large numbers. In subcutaneous inoculations 0.3 to 0.5 cubic centimeters were required. Rabbits died after intra-venous inoculation of several drops of a pure culture in 2 to 3 days, in certain instances with a purulent exudation into the joints. Fresh bouillon cultures rubbed into the skin of the ears of rabbits produced, in some instances, an erysipelatous inflammation extending over the entire ear.

Wilhelm Helm, sanitary engineer of Berlin, has made an extensive study of methods devised to improve the milk supply of cities (*Deutsche Vierteljahresschrift für öffentliche Gesundheitspflege*, Bd. XXXII, 1900). He advises the adoption of a method employed in Copenhagen for some time, in which the milk is collected at a point convenient to the producers and is pasteurized before it is shipped to the city. This arrangement permits the farmer to do his milking at more convenient hours than before. The milk is cooled as soon as possible and placed in tin cans for shipment to the pasteurizing plant. All milk is tested as to its acidity when it reaches the pasteurizing plant, and all sour milk is at once returned. The milk that is found to be still sweet is weighed and tested as to its fat content, and for the presence of water. Milk of high fat content is paid a higher price than milk of low fat content. From the scales the milk passes through two filters into a reservoir, from which it passes into the pasteurizing apparatus. The pasteurizing is accomplished by means of the exhaust system. From the pasteurizing apparatus the milk passes over the cooler into a reservoir from which it passes into the vessels used for transportation. When filled these vessels are stored in a cold chamber cooled by means of an ice machine. Before shipping the milk in hot weather, a quantity of milk ice—that is, frozen milk—is placed in each vessel. Helm was instrumental in having a number of plants of this nature constructed in the suburbs of Berlin, from which a portion of the milk supply of the city is derived.

METHODS EMPLOYED.

The samples of milk were collected in sterilized test tubes of about 20 cubic centimeters capacity, plugged with cotton. These tubes, when filled, were placed in a small tin bucket, resting within a larger tin bucket, and the space between the two was filled with cracked ice. The samples were brought to the laboratory as soon as possible after collection and the bucket containing them was placed in a large refrigerator over night. All the collections at the dairy farms were made at the time of the afternoon milking. The samples collected on the depot platforms were collected in the morning and comprised evening and morning milk, no record having been made as to the age of the milk. The source of each of these samples was, however, noted, as well as the name of the producer.

As early as possible, on the morning following the collection of milk from the dairies, the samples were plated, using 12 per cent. gelatin neutral to litmus. Duplicate plates were made from each sample, using 0.01 cubic centimeter for the one, and 0.02 cubic centimeter for the other plate. The plates were at once placed upon a level cooling apparatus and when the gelatin had become solidified they were placed in an incubator which was kept, as nearly as possible, at 20 degrees C. (68 degrees Fahr.). The temperature in the incubator was kept cool by causing a continuous flow of ice water through the air chamber between the inner and outer walls. A constant supply of ice water was secured by keeping several hundred pounds of ice in a large iron tank placed on a higher level than the incubator and connected with it by means of three-fourth inch block-tin tubing. This tubing penetrated to the bottom of the incubator on one side and the water took its exit on the other side of the incubator at the top, from whence it flowed into the sewer. By this means a fairly constant temperature was maintained within the incubator, ranging from 17.5 to 23.5 degrees C. (63.5 to 74.30 degrees Fahr.). These extremes were reached only on one or two occasions when unusual atmospheric conditions prevailed, usually the temperature ranged between 19 and 21 degrees C. (66.2 to 78.8 degrees Fahr.).

The colonies developing in the plates were counted on the third, fourth, fifth and sixth days after plating in the samples collected directly from the cows, or from the milk buckets. In the samples collected from the filtering, cooling, and bottling apparatus the counts could usually be carried to the third or fourth day only because of the presence of liquefying organisms. In the samples col-

lected from the milk cans on the depot platforms the counts had to be made on the first, second and third days; in only a small proportion of the samples was it possible to make a count on the fourth day because of the presence of large numbers of liquefying organisms.

Every sample collected was also plated with lactose-litmus agar by using one drop of milk to a tube of the melted agar. These plates were always made as soon as the gelatin plates had been completed, or from one to two hours later than the gelatin plates, according to the number of samples collected at a time. These plates were cultivated in an incubator kept at about 37.5 degrees C (99.5 degrees Fahr.). The presence of colonies of streptococcus was easily recognized after 48 hours incubation, by their size, shape, and the acid reaction of the medium surrounding them. Frequently these plates were somewhat overgrown by other organisms and in these instances no definite counts of the streptococcus colonies could be made. The results in these instances are marked with the *plus* sign. Those marked 50+ indicate, usually, the presence of a much larger number of streptococcus colonies, the number being frequently so great that no attempt was made to estimate them accurately. It must be borne in mind that the milk was dropped from a sterilized pipette, and as a different pipette was used for each sample, it is evident that the size of the drop varied somewhat. This is, however, an unimportant factor because no attempt was made to enumerate accurately the colonies of streptococcus that developed because of the difficulty encountered on account of colonies of other bacteria overgrowing the surface of the medium.

As soon as possible after the two series of plate cultures had been made from the samples collected at a dairy, the milk was centrifugalized by means of a water-motor centrifuge having a speed of about 2,000 revolutions per minute. Each sample was centrifugalized from seven to ten minutes. The sediment obtained in this manner was carefully removed by means of a small pipette, spread evenly over the surface of two coverslips, dried and fixed. After fixing, the fat was removed by washing in chloroform, and after again drying, the films were stained with Löffler's alkaline methylene blue stain. Examination was then made of both coverslips for the presence of leucocytes, pus cells, and for streptococci. In a few instances these films were subsequently decolorized and stained for the detection of the presence of tubercle bacilli. Because this method is not considered a very reliable one for the detection of tubercle bacilli in milk only a few samples were examined in this manner.

The number of leucocytes and pus cells was estimated by counting the number found in 15 to 20 separate fields in each of the coverslips and taking the mean of the results obtained. Leucocytes

or pus cells were found in practically every sample examined. The presence of a limited number of leucocytes in the sediment of centrifugalized milk appears, therefore, to be a normal condition. This has also been the experience of Stokes and Eastes. When the average number of cells exceeds five per field of the 1-12 inch oil immersion lens they usually appear in small clumps and cannot be regarded as leucocytes. When more than five cells per field are found in the sediment of centrifugalized milk I believe it is safe to state that they are pus cells. In giving the percentage of samples in each of the tables containing pus cells, I have included all those in which an average of more than five cells were found per field. Stokes also reached the conclusion that the presence of more than five cells per field of the microscope was evidence of the presence of pus, and that the milk was unfit for consumption, and stated that the cow should be removed from the dairy.

In those instances in which very large numbers of pus cells were found no very accurate determination of the actual number present could be made because of the large number overlying each other. The numbers given in these instances are based upon the relative proportions of different fields of the same coverslip that were filled with a layer of the pus cells.

RESULTS OF THE INVESTIGATION.

Bacterial counts made on milk derived from individual cows, and from dairies of different classes, to ascertain the number of bacteria in the milk of individual cows in different dairies, and of whole dairies belonging to the different classes with regard to the precautionary measures taken.

Table I shows bacterial counts, number of pus cells, and number of streptococci in milk collected directly in sterile test tubes from cows belonging to dairies of the first class.

Table I.

Number of Sample.	Bacteria per cc. of milk.	Number of pus cells per field.	Presence of streptococci in cover slip.	Number of streptococci per drop of milk.
153,	2,400	0.2	.....	28
157,	2,750	0.2	.....	25
262,	275	0.006	.....	2
264,	6,150	0.04	.....	2
264,	21,000	5.0	.....	145
295,	150	0.04	.....	12
296,	14,125	2.0	.....	108
297,	18,500	1.0	.....	2
297,	24,750	0.1	.....	15
297,	100	0.02	.....	50+
298,	18,725	0.1	.....	50+
298,	650	0.05	.....	2
298,	1,100	8.0	.....	2
304,	11,612	0.04	.....	50+
305,	650	3.0	.....	2
322,	1,250	0.1	.....	0
330,	8,075	150.0	Micrococci,	50+
331,	4,000	0.005	.....	0
332,	12,700	0.005	.....	2

This table shows the results obtained when the conditions are the best that can be devised according to our present knowledge. There was very little opportunity for air contamination. In some instances a certain proportion of the bacteria found may have been derived from the hands of the milker or the hair of the cow. I am convinced, however, that the number derived from these sources was quite small in comparison to the total number found because of the nature of the colonies. In all the samples in which the number of bacteria is unusually high the majority of these were streptococci, while the remainder of the colonies were sometimes composed of bacilli; sometimes of micrococci, or frequently of both forms. The streptococcus colonies could only be counted on the fifth and sixth day because before that time they were too small to be visible. They were always found in the depth of the medium.

Samples Nos. 158 and 159 were derived from the same cow, the one at the beginning, and the other at the close of the milking. Sample No. 330 is derived from the same cow as sample No. 14, of Table IV, the former on August 31, and the latter on July 13, and the results indicate that in the interval some inflammatory condition of the udder had developed which caused the marked difference in the two results.

Table II shows bacterial counts, number of pus cells, and number of streptococci in milk collected directly in sterile test tubes from cows belonging to dairies of the second class.

Table II.

Number of Sample.	Bacteria per cc. of milk.	Number of pus cells per field.	Presence of streptococci in coverlip.	Number of streptococci per drop of milk.
221,	1,225	0.1	.....	1
222,	300	5.0	.....	4
223,	32,800	5.0	.....	50+
224,	275	0.3	.....	1
225,	600	0.01	.....	0
237,	19,912	0.1	.....	29
238,	9,850	0.2	.....	44
239,	12,075	15.0	.....	50+
240,	4,625	15.0	.....	5
241,	2,000	5.0	Micrococci,	32
242,	325	5.0	.....	1
243,	1,000	0.005	.....	3
244,	650	0.005	.....	0
245,	800	0.005	.....	9
246,	375	0.01	.....	7
247,	3,075	0.01	.....	4
248,	100	25.0	Micrococci,	0
249,	14,500	0.2	Streptococci,	50+

This table shows the results obtained when the conditions are better than those found in ordinary dairies.

The results in this class of dairies are in many respects almost as good as those for dairies of the first class. This is explainable in the fact that the cows are carefully selected and well cared for, though the conditions of the surroundings are not so good as in dairies of the first class, consequently, somewhat higher results were generally obtained.

Samples Nos. 221 and 222 were derived from Ayrshire cows, samples Nos. 223, 224, and 225 from Jersey cows, and samples Nos. 237, 238, 239, and 240 from Guernsey cows. With the exception of one of the Jersey cows the results obtained with the milk from the Guernsey cows was far less satisfactory than would be expected from selected cows kept under good hygienic conditions. Whether certain breeds of cows are more subject to bacterial invasion of the udder than others can not be stated at the present time. This was the only dairy composed of registered stock in which the breed of individual cows was noted.

Table III shows bacterial counts, number of pus cells, and number of streptococci in milk collected directly in sterile test tubes from cows belonging to dairies of the third class.

Table III.

Number of Sample.	Bacteria per cc. of milk.	Number of pus cells per field.	Presence of streptococci in cover slip.	Number of streptococci per drop of milk.	
100.....	450	0.1	.....	97	
101.....	175	1.0	.....	100	
102.....	150	8.0	.....	50+	
103.....	100	0.01	.....	0	
104.....	125	.0	.....	0	
105.....	300	3.0	.....	0	
106.....	975	0.006	.....	0	
107.....	28,225	1.0	.....	50+	
108.....	8,050	10.0	.....	194	
109.....	3,175	0.2	.....	43	
110.....	1,150	3.0	.....	0	
111.....	41,800	10.0	.....	50+	
112.....	125	0.006	.....	1	
113.....	325	0.01	.....	0	No tubercle bacilli found.
114.....	3,300	0.05	.....	50+	
115.....	1,400	5.0	Micrococci.....	15	
116.....	9,225	2.0	Streptococci.....	50+	
117.....	375	0.2	.....	0	
118.....	17,650	25.0	Streptococci.....	50+	
119.....	2,100	0.1	.....	66	
120.....	9,600	8.0	.....	50+	
121.....	33,250	3.0	.....	50+	
122.....	17,300	5.0	Streptococci.....	50+	
123.....	21,600	35.0	Streptococci.....	21	No tubercle bacilli found.
124.....	202,450	10.0	Streptococci.....	5	No tubercle bacilli found.
125.....	205,000	250.0+	Streptococci.....	50+	No tubercle bacilli found.
126.....	2,550	0.125	.....	20	No tubercle bacilli found.
127.....	2,550	0.04	.....	3	
128.....	150	0.5	.....	1	
129.....	3,925	20.0	.....	30	
130.....	775	0.006	.....	6	
131.....	2,190	0.01	.....	25	No tubercle bacilli found.
132.....	1,175	1.0	.....	12	
133.....	10,600	5.0	Streptococci.....	7	No tubercle bacilli found.
134.....	325	3.0	.....	23	
135.....	550	5.0	.....	0	
136.....	1,450	0.1	.....	65	
137.....	12,950	300.0	.....	7	No tubercle bacilli found.
138.....	150	0.02	.....	4	
139.....	37,975	7.0	.....	50+	
140.....	200	1.0	.....	3	
141.....	200	15.0	.....	0	
142.....	100	0.005	.....	3	
143.....	1,100	0.01	.....	2	
144.....	380	0.01	.....	1	
145.....	450	0.2	.....	3	
146.....	350	3.0	.....	4	
147.....	350	0.03	.....	5	
148.....	250	0.005	.....	1	
149.....	10,925	3.0	.....	18	
150.....	1,250	5.0	.....	3	
151.....	500	0.1	.....	3	

This table shows the results obtained in dairies in which the conditions were those found commonly in the ordinary farmer's dairy. In none of these dairies were the udders cleansed before milking, and the milking was conducted in ordinary stables where no particular degree of cleanliness was exercised. In fact, in some of the dairies the conditions were the crudest and filthiest imaginable. In several of the dairies the cows were fed, while in the stable, on brewery grains, though all of the cows were in pasture during the day, and some of them day and night.

While in several instances the results obtained are as low as those obtained in dairies of the first and second class, on the whole, the results are relatively higher than those obtained in dairies of the first and second class.

The milk of several of these cows was examined for tubercle bacilli because the condition of the cows themselves or of their milk seemed to indicate the probable presence of tuberculosis, but in no instance were tubercle bacilli found by the method employed—staining of the sediment obtained by centrifugalizing the milk. This is not a very positive method for the detection of tubercle bacilli in milk, and, consequently, the negative results obtained are no evidence that tuberculosis was absent. It is possible that the cows in question were suffering from some other disease than tuberculosis, or, if the disease was present, that there was no extensive involvement of the udders.

Samples Nos. 100, 101 and 102 were derived from the same cow at different stages of the milking, and samples Nos. 106, 107 and 108 were also derived from a single cow, so were samples 154 and 155, and samples 156 and 157. The results obtained in this manner show that the number of bacteria is greatest in the first milk—the “fore” milk having been discarded.

While no estimation of the fat content of the milk was made in this investigation, the relative proportion of fat present could readily be seen in the test tubes containing the milk. With but very few exceptions the milk obtained from cows fed on brewery grains was very poor in fat. The fat content of the milk derived from several dairies of this class, which were not fed on brewery grains, was roughly estimated, and, in most instances, it was below the average.

Table IV shows bacterial counts, number of pus cells, and number of streptococci in milk collected in sterile test tubes from the milk buckets, immediately after milking, from cows belonging to dairies of the first class.

Table IV.

Number of Sample.	Bacteria per cc. of milk.	Number of pus cells per field.	Presence of streptococci in cover slip.	Number of streptococci per drop of milk.
2.	250	4.0	.....	50+
3.	2,325	10.0	.....	30
4.	4,000	0.01	.....	8
5.	1,250	0.02	.....	0
6.	600	0.01	.....	7

Table IV—Continued.

Number of Sample.	Bacteria per co. of milk.	Number of pus cells per field.	Presence of streptococci in cover slip.	Number of streptococci per drop of milk.
7.	963	0.01		20
8.	0 1	10.0	Streptococci,	0?
9.	350	1.0	Streptococci,	12
10.	1,025	1.0		10
11.	575	7.0		6
12.	275	1.0		13
13.	300	0.03		4
14.	125	.0		0
15.	1,150	0.05		50+
16.	2,400	0.1		40
17.	575	0.5		3
18.	3,100	.0		4
19.	2,350	3.0	Micrococci,	23
20.	300	0.02		50+
21.	400	0.005		5
22.	925	4.0		0
23.	650	12.0		50+
24.	56,700	4.0		50+
25.	3,225	2.0		0
26.	675	0.05	Micrococci,	1
27.	1,175	.0		8
28.	14,475	0.005		25
29.	49,300	0.03		50+
30.	750	0.005		3
31.	21,725	0.01		0
32.	12,075	4.0		4
33.	4,975	0.005		34
34.	20,650	5.0		50+
35.	12,075	0.05		73
36.	10,475	3.0		50+
37.	1,300	0.005		33
38.	6,525	0.2		50+
39.	1,075	0.005		0
40.	1,650	0.02		22
41.	2,875	3.0		25
42.	5,700	0.02		0
43.	28,325	0.2		31
44.	1,250	0.01		3
45.	31,150	10.0	Streptococci,	50+
46.	179,900	5.0	Streptococci,	50+
47.	27,750	0.05		5
48.	22,325	0.02		50+
49.	18,225	8.0		9
50.	1,525	0.005		1
51.	29,275	0.02		15
52.	7,875	3.0		50+
53.	1,775	0.01		3
54.	3,075	0.03	Micrococci,	53
55.	4,075	4.0		31
56.	36,750	5.0	Streptococci,	4
57.	375	2.0		50+
58.	2,300	8.0		63
59.	300	0.5		9
60.	1,050	0.1		50
61.	3,975	1.0		50+
62.	3,400	0.005		50+
63.	9,600	0.005		15
64.	1,675	2.0		63
65.	41,325	20.0		50+
66.	2,300	25.0		45
67.	60,300	8.0	Streptococci,	50+
68.	1,850	1.0		4
69.	4,850	50.0	Streptococci,	65
70.	1,200	0.005		11
71.	1,250	0.2		78
72.	2,500	0.005		50+
73.	4,025	15.0	Streptococci,	50+
74.	4,025	.0		33
75.	3,850	5.0		28
76.	7,750	4.0		50+
77.	70,450	0.01		50+
78.	2,400	0.005		47
79.	5,330	0.2		112
80.	2,100	2.0		2
263.	10,025	5.0	Streptococci,	50+
269.	2,250	0.5		50+
270.	1,575	0.005		8

Table IV—Continued.

Number of Sample.	Bacteria per cc. of milk.	Number of pus cells per field.	Presence of streptococci in coverslip.	Number of streptococci per drop of milk.
271.....	3,050	0.005	.....	13
286.....	4,575	3.0	.....	55
287.....	7,600	0.2	.....	55+
288.....	8,512	15.0	Streptococci,....	100
289.....	11,625	2.0	.....	19
306.....	1,350	3.0	Streptococci,....	55
307.....	12,225	4.0	.....	55
308.....	6,300	0.2	.....	45
332.....	12,075	0.012	.....	2
334.....	10,775	4.0	.....	30

This table shows the results obtained in dairies of the first class when the samples were collected from the milk buckets immediately after milking. In the first twenty-four samples the buckets were sterilized by steam after milking each cow, so that each cow was milked into a sterile bucket. The results obtained in this dairy are, relatively, much lower than those obtained in other dairies of this class where the buckets were only sterilized at the beginning of the milking. The shape of the buckets employed is also an important factor. The buckets used in the dairy where the buckets are sterilized after milking each cow are tall, narrow cylinders and there is, consequently, less opportunity for the entrance of extraneous bacteria.

Table V shows bacterial counts, number of pus cells, and number of streptococci in milk collected in sterile test tubes from the milk buckets, immediately after milking, from cows belonging to dairies of the second class.

Table V.

Number of Sample.	Bacteria per cc. of milk.	Number of pus cells per field.	Presence of streptococci in coverslip.	Number of streptococci per drop of milk.
94.....	4,975	25.0	Streptococci,....	78
95.....	11,625	5.0	Streptococci,....	107
96.....	12,150	5.0	Micrococci,....	16
111.....	7,100	1.0	.....	16

Table V—Continued.

Number of Sample.	Bacteria per cc. of milk.	Number of pus cells per field.	Presence of streptococci in covering.	Number of streptococci per drop of milk.	
112.....	2,975	0.5	.....	50	
113.....	1,375	1.0	.....	9	
114.....	335	1.0	.....	0	
115.....	400	4.0	.....	50+	
116.....	3,450	2.0	.....	12	
117.....	300	0.5	.....	23	
118.....	550	10.0	.....	20	
119.....	250	0.1	.....	0	
120.....	350	20.0	.....	55	
121.....	400	0.005	.....	12	
122.....	450	4.0	.....	50+	
123.....	1,150	0.01	.....	12	
124.....	1,750	3.0	Streptococci,.....	50+	
125.....	975	150.0	Streptococci,.....	50+	No tubercle bacilli found.
126.....	200	0.5	.....	15	
127.....	475	8.0	.....	19	
128.....	1,150	25.0	.....	30	
129.....	4,825	0.5	.....	30	
130.....	925	0.005	.....	9	
226.....	140,562	2.0	.....	50+	
227.....	441,000	0.5	Micrococci,.....	50+	
235.....	308,375	5.0	.....	50+	
236.....	154,350	35.0	Micrococci,.....	50+	
250.....	68,000	2.0	Streptococci,.....	50+	
251.....	7,475	0.5	.....	22	
252.....	5,200	0.5	.....	20	
253.....	8,350	0.05	.....	25	

This table shows the results obtained in dairies of the second class. The high results obtained for samples Nos. 226 to 236, inclusive, are explainable, in part, at least, on account of extensive alterations in the stable which were going on at the time the samples were collected in this particular dairy, though very large numbers of streptococci were found in the samples in question.

Table VI shows bacterial counts, number of pus cells, and number of streptococci in milk collected in sterile test tubes from the milk buckets, immediately after milking, from cows belonging to dairies of the third class.

Table VI.

Number of Sample.	Bacteria per cc. of milk.	Number of pus cells per field.	Presence of streptococci in cover slip.	Number of streptococci per drop of milk.	
81.....	245,350	25.0	Streptococci,....	50+	No tubercle bacilli found.
82.....	15,275	0.1	.....	140	
83.....	6,050	150.0	.....	25	No tubercle bacilli found.
84.....	5,025	15.0	.....	80	
85.....	8,350	0.01	.....	0	
86.....	151,275	2.0	.....	50+	
87.....	7,550	2.0	.....	55	
88.....	3,275	0.1	.....	15	
89.....	68,000	0.005	Micrococci,....	0	
90.....	4,450	0.2	.....	85	
91.....	95,690	5.0	Streptococci,....	50+	
92.....	8,375	0.04	.....	50+	
93.....	443,225	5.0	Micrococci,....	50+	
97.....	2,675	0.04	.....	50	
98.....	1,975	2.0	.....	61	
99.....	25,550	0.01	.....	50+	
100.....	28,600	5.0	.....	0	
104.....	40,550	5.0	.....	22	
106.....	625	0.04	.....	1	
108.....	12,475	5.0	Micrococci,....	25	
116.....	11,525	0.02	.....	92	

This table shows the results obtained in dairies of the third class when the samples are collected from unsterilized milk buckets immediately after the milking. These cows were milked in common barns in which the conditions were far from ideal.

Table VII.

Class of Dairy.	Milk Collected Directly from Cows in Sterile Test Tubes.			Milk Collected from Milking Buckets Immediately After Milking.		
	Lowest.	Highest.	Average.	Lowest.	Highest.	Average.
First,	100	24,750	8,127	00	179,800	10,732
Second,	100	23,800	5,860	200	441,000	38,468
Third,	100	205,000	13,460	625	443,225	48,623

This table shows the lowest, highest, and the average number of bacteria per sample in the three classes of dairies. The first portion of the table represents the results obtained when the samples were collected directly from the cows in sterile test tubes. The second portion of the table represents the results obtained when the samples were collected from the milking buckets immediately after

milking. The average obtained for the first class dairies is high because of rather high results from several of the samples of this series. The second portion of the table shows more distinctly the comparative effects resulting from cleanliness of utensils and care of the cows and their surroundings. It is quite evident that at other seasons of the year the contrast between the different classes would be much greater because the conditions would then be less uniform than at the time of this investigation, when there was free ventilation everywhere, so that all the milking was conducted in a freely moving atmosphere. During the winter months, when the stable doors are tightly closed, and the cows in ordinary stables have not had the cleansing effect of sunshine, rain, and fresh air in cleaning their coat, the results would, undoubtedly, be far different.

In order to determine the character of the milk delivered to the dealers by the ordinary farmer, a number of samples were collected from the milk cans on several of the depot platforms immediately after unloading from the cars.

Table VIII shows bacterial counts, number of pus cells, and number of streptococci in milk collected in sterile test tubes from milk cans on depot platforms.

Table VIII.

Number of Sample.	Bacteria per cc. of milk.	Number of pus cells per field.	Presence of streptococci in cover slip.	Number of streptococci per drop of milk.
131.	304,925	50.0	Streptococci,.....	50+
132.	447,600	25.0	Streptococci,.....	50+
132.	3,042,900	0.02	Streptococci,.....	50+
134.	1,013,425	50.0	Streptococci,.....	50+
135.	10,000,000+	12.0	Streptococci,.....	50+
136.	261,525	4.0	Streptococci,.....	50+
137.	2,721,600	5.0	Streptococci,.....	50+
138.	226,400	50.0	Micrococci,.....	50+
139.	10,000,000+	150.0	Streptococci,.....	50+
140.	3,704,400	30.0	Streptococci,.....	50+
141.	45,300	25.0	Streptococci,.....	50+
142.	10,000,000+	25.0	Streptococci,.....	50+
143.	340,550	150.0	Streptococci,.....	50+
144.	2,062,287	5.0	Streptococci,.....	50+
145.	481,425	0.02	Micrococci,.....	50+
146.	329,325	200.0	Streptococci,.....	50+
147.	148,200	20.0	Streptococci,.....	50+
148.	154,950	35.0	Micrococci,.....	50+
149.	170,225	8.0	Streptococci,.....	50+
150.	182,150	8.0	Streptococci,.....	50+
151.	33,000	5.0	Streptococci,.....	217
160.	658,700	15.0	Streptococci,.....	50+
161.	2,343,600	18.0	Streptococci,.....	50+
162.	5,904,700	5.0	Streptococci,.....	50+
163.	646,800	25.0	Streptococci,.....	50+
164.	3,307,000	30.0	Micrococci,.....	50+
165.	52,175	50.0	Streptococci,.....	50+
166.	210,000	8.0	Micrococci,.....	50+
167.	324,800	25.0	Micrococci,.....	50+

Number of Sample.	Bacteria per cc. of milk.	Number of pus cells per field.	Presence of streptococci in coverlip.	Number of streptococci per drop of milk.
168,	956,400	5.0	Micrococci,	50+
169,	744,175	0.1	Micrococci,	50+
170,	457,800	50.0	Streptococci,	50+
171,	921,200	12.0	Micrococci,	50+
172,	266,575	75.0	Streptococci,	50+
173,	380,200	1.0	.....	50+
174,	488,950	1.0	Micrococci,	50+
175,	2,119,075	5.0	Streptococci,	50+
176,	53,750	35.0	.....	50+
177,	2,696,400	35.0	Streptococci,	50+
178,	632,150	8.0	Streptococci,	50+
179,	2,206,000	10.0	Streptococci,	50+

This table shows the condition of milk when collected from the cans on the depot platforms immediately after reaching the city. It will be seen that most of this milk is not very desirable for human consumption not only on account of the enormous number of bacteria present, but also on account of the very high percentage of samples containing pus—70.73 per cent.—and the presence of large numbers of streptococci in each sample. This milk is undesirable for consumption not on account of filthy methods of collection and storing alone, but on account of diseased cows in most of the herds from which these samples were derived. The relatively bad quality of this milk is shown more graphically in Table XIII, which shows the summaries of all the preceding tables; except Table VII.

Table IX shows bacterial counts, number of pus cells, and number of streptococci in milk collected from the cooling and bottling apparatus of a dairy of the first class in which the buckets are sterilized after each cow is milked, and in which all the utensils are sterilized by steam before the milking is commenced.

Table IX.

Number of Sample.	Bacteria per cc. of milk.	Number of pus cells per field.	Presence of streptococci in coverslip.	Number of streptococci per drop of milk.	
290,.....	11,375	3.0	.....	25	Cooler.
292,.....	2,125	3.0	Micrococci,.....	10+	Cooler.
294,.....	7,425	5.0	.....	50+	Cooler.
296,.....	4,850	0.02	.....	11	Cooler.
321,.....	21,200	35.0	Streptococci,.....	50+	Cooler.
322,.....	18,950	3.0	.....	50+	Cooler.
325,.....	32,400	3.0	.....	50+	Cooler.
326,.....	19,600	0.2	.....	50+	Cooler.
329,.....	25,875	0.5	.....	50+	Bottling tank.
333,.....	6,900	9.02	.....	54	Bottling tank.
336,.....	1,875	10.0	.....	10+	Bottling tank.
337,.....	7,975	0.5	.....	10+	Bottling tank.
338,.....	17,900	3.0	.....	50+	Bottling tank.
339,.....	25,925	10.0	.....	50+	Bottling tank.
341,.....	94,750	0.5	.....	30	Bottling tank.
335,.....	49,000	0.6	.....	50+	Bottling tank.

Table X shows bacterial counts, number of pus cells, and number of streptococci in milk collected from the cooling and bottling apparatus of a dairy of the first class in which the buckets are only sterilized at the beginning of the milking.

Table X.

Number of Sample.	Bacteria per cc. of milk.	Number of pus cells per field.	Presence of streptococci in coverslip.	Number of streptococci per drop of milk.	
272,.....	13,400	2.0	.....	50+	Filter.
297,.....	23,625	4.0	.....	31	Filter.
298,.....	9,350	0.2	.....	10+	Filter.
305,.....	14,150	0.2	.....	8	Filter.
314,.....	125,000	3.0	Micrococci,.....	50+	Filter.
273,.....	3,850	5.0	.....	31	Tank below filter.
278,.....	13,050	0.04	.....	42	Tank below filter.
299,.....	200,000	0.5	.....	50+	Tank below filter.
310,.....	11,375	0.1	Micrococci,.....	10+	Tank below filter.
315,.....	200,000	3.0	.....	50+	Tank below filter.
274,.....	17,500	0.2	.....	49	Star cooler.
299,.....	9,650	2.0	.....	57	Star cooler.
300,.....	125,000	0.2	.....	50+	Star cooler.
311,.....	12,025	1.0	.....	25	Star cooler.
315,.....	73,520	1.0	Micrococci,.....	50+	Star cooler.
275,.....	29,625	0.065	.....	20	Tank below cooler.
280,.....	33,075	5.0	.....	35	Tank below cooler.
301,.....	150,000	0.1	Micrococci,.....	50+	Tank below cooler.
312,.....	13,775	0.01	.....	50+	Tank below cooler.
317,.....	22,100	0.2	.....	11	Tank below cooler.
276,.....	63,216	2.0	.....	50+	Bottler.
281,.....	529,200	1.0	.....	50+	Bottler.

Number of Sample.	Bacteria per cc. in milk.	Number of pus cells per field.	Presence of streptococci in cover slip.	Number of streptococci per drop of milk.	
302.....	95,280	0.5	.....	50+	Bottler.
312.....	140,000	0.1	.....	50+	Bottler.
318.....	39,280	1.0	.....	50+	Bottler.
1.....	12,350	.....	.....	.....	Bottles supplied consumers.
319.....	12,525	0.005	Micrococci,	50+	Bottles supplied consumers.
320.....	22,000	0.5	.....	50+	Bottles supplied consumers.

Table XI shows bacterial counts, number of pus cells, and number of streptococci in milk collected from a dairy of the second class, in which the stable floor was undergoing reconstruction, and, consequently, there was more or less dust in the air of the stable.

Table XI.

Number of Sample.	Bacteria per cc. of milk.	Number of pus cells per field.	Presence of streptococci in cover slip.	Number of streptococci per drop of milk.	
223.....	1,170,475	5.0	Micrococci,	50+	Cooler.
225.....	1,444,275	1.0	Micrococci,	50+	Cooler.
230.....	519,800	5.0	Streptococci,	50+	Cooler.
231.....	693,008	1.0	.....	50+	Tank.
232.....	1,325,450	1.0	Streptococci,	50+	Tank.
233.....	912,580	15.6	Micrococci,	50+	Tank.
234.....	1,162,816	0.05	Micrococci,	50+	Bottler.

Table XII shows bacterial counts, number of pus cells, and number of streptococci in milk collected from a dairy of the second class in which the utensils are not sterilized.

Table XII.

Number of Sample.	Bacteria per cc. of milk.	Number of pus cells per field.	Presence of streptococci in coverslip.	Number of streptococci per drop of milk.	
254,.....	57,975	2.0	Micrococci,	50+	Can.
255,.....	40,075	1.0	Micrococci,	50+	Can.
256,.....	88,175	5.0	Micrococci,	100	Strainer.
257,.....	139,650	5.0	.....	107	Strainer.
258,.....	112,950	0.5	.....	63	Cooler.
259,.....	76,775	0.2	Micrococci,	75	Cooler.
260,.....	54,500	3.0	.....	50+	Tank.
261,.....	76,175	6.0	Micrococci,	65	Tank.

Tables IX and X show the results as obtained from the straining, cooling and bottling apparatus employed in the first class dairies. In comparing these results with the results shown in Table IV it will be seen that the proportion of bacteria has been increased more or less regularly by each of the different steps of the process. Tables XI and XII show the same facts for dairies of the second class, and here the results are similar to those obtained with dairies of the first class except that the bacterial counts are uniformly high. This is especially the case with the dairy tabulated in Table XI, in which, for some reason or other, the proportion of streptococci was very high, and the number of other bacteria present was unusually high because the stable was undergoing extensive alterations at the time of collecting the samples.

Table XIII shows the relative proportion of pus cells in the different samples as tabulated in Tables I to VI, and VIII.

Table XIII.

Table.	Percentage of Pus Cells.	
	Present.	Absent.
I,.....	10.53 per cent.	89.47 per cent.
II,.....	16.78 per cent.	83.22 per cent.
III,.....	23.07 per cent.	76.93 per cent.
IV,.....	15.22 per cent.	84.78 per cent.
V,.....	22.53 per cent.	77.47 per cent.
VI,.....	16.29 per cent.	83.71 per cent.
VIII,.....	70.73 per cent.	29.27 per cent.

The results obtained in the three classes of dairies when the samples are collected directly in sterile test tubes are in line with those obtained by Stokes, though the differences in the different classes are not as great as shown in his investigation. When the samples are collected from the milking bucket there is less uniformity in the relative increase in the number of pus cells as we proceed from class one to class three, in fact the proportion for class two is somewhat high. This is explainable, no doubt, on account of the relatively small number of samples included in Table VI, showing the results for class three. It must also be borne in mind that at the time of collecting the samples, the hygienic conditions of the surroundings of the dairies of the different classes did not vary to such a marked extent because all the cows were practically in pasture day and night, and had been so for several months. In consequence of this fact any abnormal condition of the system of the cows of the third class, brought about by bad hygienic surroundings during the past winter, had ample time to be relieved by the improved conditions under which they had been living for several months past. This improvement in the general health of the cows would evidently be greatest in those belonging to class three because the contrast between their surroundings in winter and summer is greatest. Moreover, the grade of cows found in the common dairies is such that they would probably respond most markedly to the effects of improvement in their surroundings. The results obtained with milk collected on the depot platforms show more definitely the character of milk derived from cows belonging to the third class. These samples were derived principally from the ordinary farmers' dairy, and are, therefore, indicative of the conditions surrounding dairy herds of this class. It is evident that if a larger number of samples had been examined of the class included in Table VI the results would have coincided more definitely with those obtained for the mixed milk of ordinary dairies as shown in Table VIII.

Examinations were also made in the first and second class of dairies in order to determine the degree of pollution of the milk through the processes of straining, cooling and bottling. The results are shown in Tables XIV, XV, XVI and XVII. These tables show the lowest, highest and the average number of bacteria found in samples taken from the first and second class dairies at different points in the operation of collecting and storing the milk.

Table XIV shows the comparative results obtained in one of the dairies of the first class. In this dairy all the utensils are sterilized by means of steam immediately before beginning to milk and the milk buckets are sterilized after milking each cow. The table shows the lowest, highest and average number of bacteria found in the milk in the different steps from the cow to the bottling tank. It will be

seen that there is a gradual increase in the number of bacteria, as shown by the average results, from the cow to the last step in the process, so that, apparently, bacteria are gaining entrance to the milk at each point.

Table XIV.

Milk Collected Directly from Cows in Sterile Test Tubes. (8 samples.)			Milk Collected from Milking Buckets Immediately After Milking. (31 samples.)		
Lowest.	Highest.	Average.	Lowest.	Highest.	Average.
100	12,725	4,872	00	56,700	4,727

Milk Collected from Star Cooler. (8 samples.)			Milk Collected from Bottling Tank. (8 samples.)		
Lowest.	Highest.	Average.	Lowest.	Highest.	Average.
2,125	22,400	14,741	1,875	94,760	29,150

Table XV shows results obtained in another dairy of the first class in which samples were collected at various stages in the collection and storing of the milk. In this dairy the utensils are only sterilized at the beginning of the milking. A special milking stable has been constructed and all the operations are conducted as carefully as possible.

The results obtained in this dairy do not show the same relative increase in the number of bacteria for each of the steps in the process as shown in Table XIV. This may be due to the fact that the dairy is a large one and the samples were collected from each of the points on several different days. Those collected on the same day were also collected at different stages of the process of milking, some soon after beginning the milking, and some near the close of the milking; more than an hour having elapsed between the collection of the first and last sets of samples.

Table XV.

Milk Collected Directly in Sterile Test Tubes. (9 samples.)			Milk Collected from Milking Buckets, Which Were Sterilized only at the Beginning of the Milking. (61 samples.)		
Lowest.	Highest.	Average.	Lowest.	Highest.	Average.
150	21,000	7,635	300	179,900	13,849

Milk Collected from the Filter. (5 samples.)			Milk Collected from Tank Below Filter. (5 samples.)		
Lowest.	Highest.	Average.	Lowest.	Highest.	Average.
9,350	125,000	37,105	8,850	200,000	35,635

Milk Collected from the Cooler. (5 samples.)			Milk Collected from Tank Below the Cooler (5 samples.)		
Lowest.	Highest.	Average.	Lowest.	Highest.	Average.
9,650	125,000	47,535	13,775	150,000	49,715

Milk Collected from the Bottler. (5 samples.)			Milk Collected from Bottles Supplied to Con- sumers. (3 samples.)		
Lowest.	Highest.	Average.	Lowest.	Highest.	Average.
63,216	529,200	173,363	13,350	22,200	13,350

Table XVI shows the results obtained in a dairy of the second class, the samples being collected at various stages of the process of milking, cooling and bottling of the milk. The results are much higher than those obtained in dairies of the first class. The character of the results obtained is traceable largely to the fact that extensive alterations of the stables were in progress at the time of collecting the samples. When all these alterations are completed and other precautionary measures are carried out systematically this dairy should be included in the first class, but under the existing conditions it belongs in the second class.

Table XVI.

Milk Collected Directly from Cows in Sterile Test Tubes. (9 samples.)			Milk Collected from Milking Buckets Immediately After Milking. (4 samples.)		
Lowest.	Highest.	Average.	Lowest.	Highest.	Average.
275	22,800	9,125	140,563	441,000	261,197

Milk Collected from Star Cooler. (3 samples.)			Milk Collected from Tank Below Cooler. (2 samples.)		
Lowest.	Highest.	Average.	Lowest.	Highest.	Average.
517,900	1,444,275	1,044,217	693,000	1,325,450	1,009,225

Milk Collected from Bottler. (2 samples.)		
Lowest.	Highest.	Average.
913,500	1,162,816	1,038,153

Table XVII shows the results obtained in another dairy of the second class. The conditions prevailing at this dairy are superior to those found in the ordinary farmers' dairy. The stables are clean and the cows are of selected grade. The milk house is close to the stables and is open to considerable improvement. The straining and cooling apparatus is placed under an open veranda at the milk house, so that the exclusion of dust is out of the question.

Table XVII.

Milk Collected Directly from Cows in Sterile Test Tubes. (8 samples.)			Milk Collected from Buckets Immediately After Milking. (4 samples.)		
Lowest.	Highest.	Average.	Lowest.	Highest.	Average.
325	14,500	2,253	5,200	63,000	22,244

Table XVIII—Continued.

Milk Collected from Can at Stable into Which Milk Is Poured to Carry to Milk House. (2 samples.)			Milk Collected from Strainer. (2 samples.)		
Lowest.	Highest.	Average.	Lowest.	Highest.	Average.
40,075	57,975	49,025	83,175	139,050	113,912

Milk Collected from Cooler. (2 samples.)			Milk Collected from Tank Below Cooler. (2 samples.)		
Lowest.	Highest.	Average.	Lowest.	Highest.	Average.
76,775	113,950	94,863	54,500	76,175	65,337

Tables XIV and XV show the lowest, highest and average number of bacteria per sample for dairies of the first class at various stages in the operations of collecting and storing the milk. Tables XVI and XVII show the lowest, highest and average results obtained at the different points of the operations in collecting the milk from the cow to the bottling apparatus in dairies of the second class. These show that there is an increase in bacteria due to the contaminations from the bucket and the hands of the milker, and the air of the stable, and from the various utensils and apparatus employed.

SUMMARY.

The results of the investigation show that bacteria gain entrance to milk at all of the various steps of the milking operation, and in cooling and bottling the milk, and that the number of bacteria gaining entrance is dependent very largely upon the degree of cleanliness of the milker, upon the nature of the stable in which the milking is conducted, upon the cleanliness of the utensils employed, and especially upon the faithfulness with which all these precautionary measures are carried out from day to day. In the different samples

examined the proportion in which contamination with the colon bacillus was found was relatively small. No record was taken of these samples because this form of contamination seemed to be comparatively rare. The prevalence of colon bacilli was, however, constantly greatest in those dairies in which the udder was not washed or carefully brushed previous to the milking, so that this operation is no doubt of great value in the sanitary collection of milk.

Eight samples of milk derived from individual cows, belonging to the first class of dairies, were injected intraperitoneally into guinea pigs, in amounts ranging from 1.75 to 3.5 cubic centimeters. Only three of these animals died, and in two instances cultures made from the peritoneal cavity and the different organs showed the presence of large numbers of staphylococci, a few chains of streptococci, and numerous short, slender bacilli. Death evidently resulted from the staphylococcus pyogenes aureus infection because these organisms preponderated to a marked extent. In the third guinea pig, which died 20 days after inoculation, no bacteria were found, and no definite lesions.

Cultures of streptococci were isolated from several samples of milk and three of these were inoculated into the skin of the ear of rabbits. In each instance there was slight oedematous inflammation of the skin of the ear around the points of inoculation, but in no instance did the inflammation extend over the entire ear. The inflammation subsided entirely in 3 to 5 days, without causing any systemic disturbances.

Another of the cultures of streptococci isolated from one of the samples of milk was inoculated intraperitoneally into two guinea pigs; half a cubic centimeter of a twenty-four hour old bouillon culture being used in both instances. These animals remained apparently well. In connection with these few experiments it must be borne in mind that Beck's inoculations were made with mixed milk, and had milk of this character been employed in these experiments, the results would, no doubt, have been quite different. The samples of milk inoculated intraperitoneally into guinea pigs were Nos. 264, 268, 272, 273, 286, 288, 292, and 295. The animals that died had been inoculated with samples Nos. 272, 273 and 288, respectively. The cultures of streptococci employed in the inoculation of the rabbits' ears were derived from samples No. 253, 278, and 281. The culture of streptococcus employed in the intraperitoneal inoculation of the guinea pigs was derived from sample No. 306.

This investigation has two phases, economic and hygienic, and the results show that the economic conditions are influenced directly by the hygienic conditions of the cows themselves, the character of the stables, and the degree of cleanliness exercised in collecting, storing

and marketing the milk. In the dairies of the first class in which the greatest care is exercised in all the details necessary to the sanitary production of milk the results show that notwithstanding this care and the discrimination in the selection of cows, in their care and feeding and so on, that the number of bacteria contained in the milk of such cows is in many instances very high. The large number of bacteria contained in the milk of certain individual cows in such dairies appears to be largely of one class, namely streptococci. The character of the bacteria contained in largest numbers in the milk therefore made the investigation a somewhat tedious and difficult one, because streptococci do not grow very rapidly, and never form large colonies in gelatin plates, and consequently a longer time had to be allowed for their development to a sufficient size to enable one to make satisfactory counts. For this reason the plates made from milk derived from individual cows were counted up to and including the sixth day. In all the instances of dairies of the first and second classes, and in dairies also of the third class, where the samples were collected directly from the cows, the high counts were due almost altogether to streptococci. As to the nature of these streptococci, I am unable to give any positive opinion. Eastes states that milk which contains pus or muco-pus and streptococci is unfit for human consumption. Beck believes that these streptococci are closely related with those which Escherich found in infantile enteritis, and states that Romme also believes that they are the cause of severe forms of colitis in children.

The season of the year at which this research was conducted, being such that all cows were out at pasture, most of them day and night, gives us conditions which are not altogether allied with those found by Stokes of Baltimore, by Eastes of London, and Beck of Berlin. Eastes states that in his experience milk derived from pasture fed cows is less likely to be contaminated than that from cows which are stall-fed, and Stokes' results show that the percentage of pus cells in stall-fed cows, and cows kept under unhealthy conditions, is many times greater than that of cows kept in well lighted and ventilated stables, and fed on grains and cut hay. I was unable to show this marked difference in results in cows belonging to the different classes, but reference to Table XIII will show that the percentage was appreciably higher for the dairies of the third class in which the cows were fed on brewery grains.

When one takes into consideration the results that have been obtained not only in the present investigation, but those obtained by Beck, by Eastes and others, it is easy to comprehend the difficulty encountered in producing a satisfactory milk for general consumption. In the first class dairies, the measures which are em-

ployed to bring about this end are in general those approved by the most competent authorities on the subject, and no expense has been spared to render the results as satisfactory as possible; yet the results which I have obtained in the examination of milk derived from these dairies are still far from satisfactory. They are far from the ideal results, or even from the results which one would reasonably expect to obtain with milk from these sources. According to the results obtained by Beck by means of a far more trustworthy method, that of direct inoculation of the milk into susceptible animals, the proportion of cows to be condemned on this account is somewhat lower—62.5 per cent. The results of Eastes indicate that about 80 per cent. of the cows would have to be condemned. Such a recommendation is entirely out of the question not only because of the expense involved, the enormous losses entailed, but because the indications are that it is impossible to produce sufficient milk that is absolutely without objection at the time it leaves the cow's udder, to supply the demand.

CONCLUSIONS.

The following conclusions may be drawn from the results of the investigation:

1. Milk drawn directly from the udder in the manner employed in ordinary milking, and collected in sterile test-tubes, was always found to contain bacteria and most of these organisms appeared to belong to the group of streptococci. The number of bacteria in the first milk was usually found to be greater than the number found toward the last of the milking.

2. In those instances where the milking buckets were sterilized by means of steam before commencing the milking and after milking each cow, the number of bacteria found was but little higher than when the samples were collected directly from the cows.

3. In those instances where the milking buckets were not sterilized, or only at the beginning of the milking, the number of bacteria found was apparently higher than when the milk was collected directly from the cows. The greater the care in milking, and the better the hygienic conditions of the cows and their surroundings, the lower the results obtained. Table VII shows more definitely the influence of the hygienic conditions on the number of bacteria found.

4. The enormous increase in the number of bacteria during shipment is shown on comparing Table VIII with the previous tables giving the results when the milk is stored in sterile vessels. The results obtained with the milk collected on the depot platforms, as compared with those obtained in dairies of the first class, indicate that there is much room for improvement in the methods of collection and shipment as practiced by the ordinary dairy farmer.

5. The studies made with samples of milk collected from the filtering, cooling and bottling apparatus indicate that at each of these points some bacteria gain access to the milk, the more complicated the apparatus employed the greater the number of bacteria found, and, consequently, the apparatus employed for this purpose should be as simple as possible commensurate with the objects that are to be attained. The apparatus should be so constructed that it can be easily disconnected, cleaned, and sterilized.

6. A few leucocytes were found in practically all milk examined, and this appears to be an entirely normal condition. When the average number of cells present in a field of the 1-12 inch lens is greater than five they are usually found to be aggregated in small clumps, and when this condition was found they were designated as pus cells, and are believed to indicate a pathological condition of the udder.

7. The prevalence of pus cells in the milk appeared to be influenced directly by the hygienic condition of the cows, as indicated by the greater proportion found in cows of the third class of dairies. The presence of pus cells in the milk of cows of the first and second classes seems to indicate that the condition is influenced to some extent by other conditions, probably by the character of the food. In no instance was acute inflammatory disease of the udder found.

8. While no very positive evidence was obtained of any pathogenic effect of the streptococci in the milk when inoculated into guinea pigs and rabbits, it is most probable that when these organisms are present in the large numbers sometimes found in the samples, that they would prove injurious to infants or sick persons when such milk is taken in considerable quantities.

GLOSSARY.

Bacillus (plural **bacilli**), a rod-shaped organism.

Bacteria (singular **bacterium**), the smallest forms of vegetable organisms, composed of a single cell.

Centrifugalize, to separate suspended particles in fluids by means of a centrifugal machine.

Colony, an aggregation of bacteria that have developed from a single organism in a solid culture medium.

Cubic centimeter, a volume equal to 1-960 part of a quart.

Incubator, a double-walled chamber, which is maintained at a uniform temperature, in which the cultures of bacteria are placed for cultivation.

Inoculation, the act of transferring bacteria from one medium to another, or from a medium into the tissues of an animal.

Leucocytes, the white corpuscles of the blood of man and the higher animals.

Micrococcus (plural **micrococci**), bacteria that are spherical in shape.

Micro-organism, any microscopic form of life, but usually referring to the class bacteria; a bacterium.

Organism, any form of life that maintains an independent existence.

Pathogenic, having the power of producing disease.

Pus cells, dead leucocytes and other cells contained in pus.

Staphylococcus (plural **staphylococci**), spherical bacteria that group themselves in irregular bunches; the bacteria which are concerned in the production of inflammation, abscesses, carbuncles, etc.

Sterile, free from all kinds of microscopic life.

Sterilize, to render free from microscopic life; usually brought about by means of heat.

Streptococcus (plural **streptococci**), spherical bacteria which group themselves in the form of chains.

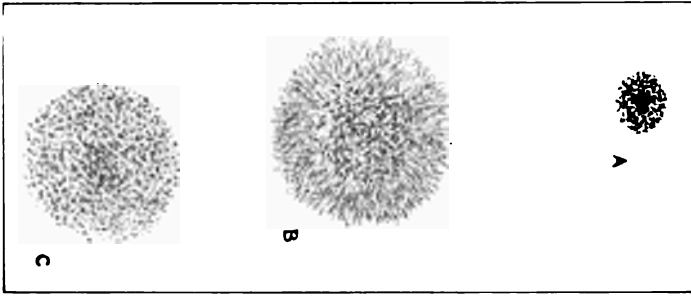


Fig. 1. Different forms of colonies.

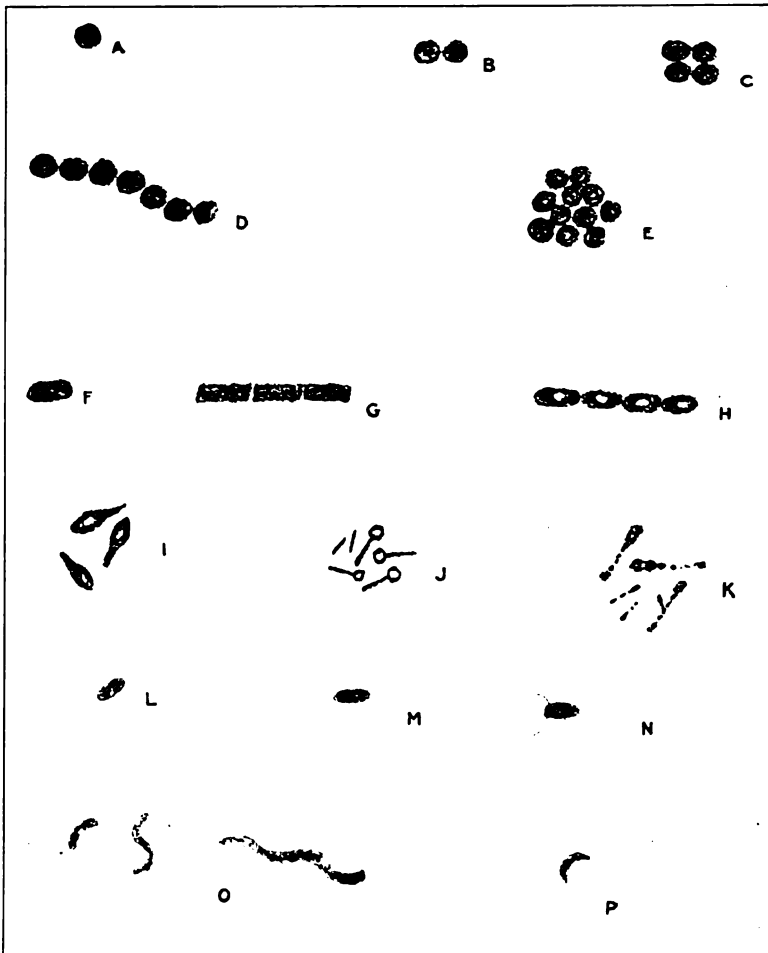


Fig. 2. Different forms of bacteria.

DESCRIPTION OF PLATES.

Fig. 1:

- a. Colony of *streptococcus pyogenes*.
- b. Colony of *bacillus subtilis*.
- c. Colony of *staphylococcus pyogenes aureus*.

Fig. 2:

- a. A single coccus.
- b. A diplococcus.
- c. A tetracoccus.
- d. A chain of streptococci.
- e. A group of staphylococci.
- f. A single bacillus with rounded ends.
- g. A chain of bacilli with square ends.
- h. A chain of bacilli with rounded ends, showing spores.
- i. Bacilli with spores, shaped like a javelin.
- j. Tetanus bacilli showing spores at one end.
- k. Diphtheria bacilli, showing club-shaped, and branching forms.
- l. A bacillus showing one polar flagellum.
- m. A bacillus showing flagella at both poles.
- n. A bacillus showing numerous flagella.
- o. Different forms of spirilla.
- p. A spirillum showing a polar flagellum.

THE EFFECT OF SMOKE AND GAS UPON VEGETATION.

W. A. BUCKHOUT, M. S., *Botanist, Pennsylvania Agricultural Experiment Station.*

There is an impression, more or less widespread, that the large quantities of smoke and the gases which escape into the atmosphere in localities where extensive manufacturing operations are carried on are a direct injury to vegetation. This is almost entirely founded upon general observation and tradition; for, although sympathetic injuries have, in several cases, made awards to farmers and others, for injuries from the smoke and fumes of coke ovens and other manufacturing plants, it has generally been upon miscellaneous general evidence, and has not included any founded upon scientific examination and determination. There are many instances, it is true, where the facts are so plain and open that nothing further is needed; where the distance between the source of the noxious substance and the injured vegetation is so short, or the effects have followed so directly upon sudden production of smoke or gas, and stopped when they stopped, that there was no further room for doubt; hence, no evidence from a scientific investigation has been necessary. It must, however, be evident, that there is a broad borderland between the distinctly injured territory and that which is so remote from it that it may be assumed to be unaffected. The limits of such borderland and the degree and character to which vegetation therein is affected, are points which call for a careful collection and comparison of facts of every kind and from every available source.

It was in response to the appeal for more knowledge upon this particular phase of the subject that the present inquiry was undertaken. The writer has made some personal examination of localities from which complaint has come or which have been under suspicion, and has been at considerable pains to study the question both from the practical and the theoretical sides. Like so many other questions affecting the cultivator and the landholder, this one has been most thoroughly and exhaustively investigated in Germany and other foreign countries, and a knowledge of experiment and research elsewhere becomes imperatively necessary. Indeed, particularly from the standpoint of chemical analysis, which is all-important, this work has been so completely done by the classic researches of Schroeder and Reuss in their report entitled, "*Beschadigung Der*

Vegetation Durch Rausch und Die Oberharzer Hüttenrausch Schaden," that there is no sufficient occasion for repetition, inasmuch as in a matter of this kind the difference between conditions in this country and Germany becomes quite insignificant, since the fundamental principles of plant physiology and the nature and action of chemical substances are substantially the same everywhere. Hence, we may use the results of these investigators with such change only as minor considerations may render necessary.

That there should be need of some careful investigation of this question is not surprising when one sees the lamentable agricultural and forestal conditions which prevail in some sections of our State. Nevertheless, there is special occasion for extreme care and caution not to make mistake by misrepresenting facts, nor to draw false conclusions by correlating causes and results which have no true connection. It should be constantly borne in mind that there are very many reasons for unhealthy or for dying plants; and, that not unfrequently, two or more factors may be associated in producing a given result. Only by great care and patient examination can the effects of these different factors be isolated and thus mistaken inferences avoided and true relationships determined.

Before a knowledge of the life history of insects was known, the maggots found rioting in the rotting carcass of a dead animal were thought to be the cause of that animal's death, or as the result of spontaneous transformation of its tissues. We now see how absurd such ideas are, because the true nature of a maggot and all the details of the curious life history of which it forms so conspicuous a part have been fully studied out and confirmed by many different investigators working independently of one another. The question of the influence of smoke and various gases upon vegetation is an exceedingly complicated one because of the number of factors concerned, their invisibility, indeed their inappreciation by ordinary means, and, especially, their exceedingly variable relations. No positive conclusions should be drawn until the nature and effect of each of these factors have been carefully isolated. This calls for chemical analysis and experiment, as has been just noted, and likewise careful field examination and comparison. Only in this way can any sound conclusions be obtained. It is in this spirit and by this method that the writer has endeavored to approach the question. The different steps in this investigation, the reader is invited to follow with care if he would be saved from hasty and unwarranted conclusions.

THE NATURE AND LIFE ACTION OF PLANTS.

No clear understanding of plant diseases or injuries can be had without some knowledge of the general make-up of plants and the

way in which the different parts perform their functions. Especially is it necessary in such a case as this to review the general facts of anatomy and physiology before proceeding to the consideration of those injuries which one may suspect come from unfavorable or poisonous surroundings. The normal conditions must be known before one can understand the abnormal; conditions in health before one can make correct diagnosis of disease or prescribe a remedy. All plants, no matter of what grade or kind, are made up of minute bodies, generally invisible to the naked eye, called cells, which vary greatly in size, shape and other details, but which are all alike in containing, when young and active, a living substance, protoplasm by name, to which their activities are due. These cells can be plainly seen by a compound microscope, and sometimes by much simpler means, when the leaf or whatever part which may have been taken is properly handled. It is not possible, bear in mind, to see and understand these parts without careful manipulation, such as cutting exceedingly thin sections of plant leaves and stems, and viewing them with a compound microscope properly adjusted and illuminated. In some special cases the protoplasm and other cell contents may likewise be seen, and the various phenomena connected therewith studied and experimented upon. By the labors of the anatomist we may thus become acquainted with the make-up of the typical cell, the unit of all plant structure.

While the use of the young cell is to serve as the vehicle of life, many cells sooner or later perform other functions, such as protection to the active parts, strengtheners and supporters, as in stems, the veins of leaves, etc. Sometimes several functions even are combined in one cell and carried on at one time. Masses of cells of the same kind make up a tissue, and different tissues are in turn collected together to make up an organ, as the leaf, the bark, etc. Most cells lose their protoplasm and hence their life and activity in a short time; thereafter they serve only the subsidiary functions of protection and mechanical support. It is thus that a plant may in time reach even the stature and age of a forest tree, in which only a limited number of cells of the leaves, young twigs, bark and wood of the current year are alive; all else has passed the sphere of activity and has become the passive protector and supporter of the living.

It is much easier to understand what cells are than it is to understand what cells do. Details of structure, however minute, may be made visible and evident to the eye; details of action are seldom recognized by such means. It would be foreign to the purpose and intent of this paper to undertake a full exposition of plant physiology; a few only of the most marked activities may be considered.

The general relation of plants to water is particularly important to understand and continually to bear in mind. Water is essential to all plant life and makes up a large part of every plant. It is imbibed by cells, such as those of the root, which are in contact with the external source of supply, and as they become satisfied and turgid, it is passed on from one to the other until it reaches the points which are using water in some of the many processes of growth, or until it reaches the outer layers from which it is transpired into the atmosphere. This action in all rapidly growing plants is quite rapid. The sudden wilting of a leafy stem which has been plucked or the shriveling of the blades of corn under a hot sun, and their becoming plump again so soon as the sun has passed, are familiar examples of a water movement which we cannot see in itself, but of which there are various methods of easy proof. When this transpiration for any reason becomes excessive, the leaves or other parts, the cells of which are losing more water than is necessary to sustain life, become dead and the tissue which they compose dry and at length brown and discolored. The scorched appearance which many leaves or even entire trees may show is sometimes due to nothing else but cutting off the water supply. This may be done in a great variety of ways. For instance: The burned appearance which many forest trees in Westmoreland and other western counties of the State were showing during the summer of 1900 was due, in many instances, noted by the writer, to the cutting off of the water supply of many small twigs and branches. These twigs had been used by the 17-year locusts, or cicadas, as depositories for their eggs. The piercing of the tissues of the twigs by the insect's ovipositor, so cut and disarranged the conducting cells that the water was cut off from the leaves, and one by one they withered and died. Generally in such cases the twig also dies in time and may be broken off by the wind and carried to the ground. These later changes are determined by time and the degree of injury. The first withering and browning of the leaves comes from the interruption in water supply only and their consequent death, together with the disorganization of their green and other cell contents. This case, so simple and easily explained, every detail of which has been verified over and over again, by different persons and in different places, has been variously explained by casual observers. "It is caused by a late spring frost," "by drought," "by smoke and gases in the atmosphere," "by fire," "by blight"—whatever that may be. The special advantage of mentioning this case is that it furnishes so good an opportunity to refer an effect to its plainly visible cause. Very similar results may follow from other cases, invisible, intangible; then the difficulties of interpretation and the danger of mistaken reference become greatly increased. While water is so important in the econ-

omy of plant life and enters into the life processes to so large an extent, other substances are absorbed and circulate with it and are more or less necessary to life and healthy growth; hence, their absence results in a feebleness of growth and nutrition, a lack of normal color or an unfruitfulness, conditions which it is often impossible in our present state of knowledge, satisfactorily to explain.

The food of plants, however, is largely drawn from the atmosphere. This, again, is so subtle and impalpable a medium that we are slow to appreciate it and its importance in plant life. It appears more reasonable, so to speak, that the earth should be the great reservoir of plant food and water the medium by which such food is drawn into and made available for life and growth. But the part taken by the atmosphere is a very large one and indispensable. From it comes directly the carbon in the form of carbon dioxide which enters, more particularly, through the leaves, and by the subtle alchemy of the sunlight becomes separated into its two components, one of which combines with the other elements close at hand to serve the needs of the plant, while the other, the oxygen, escapes back to the outer air again. This process, so essential to green plants, cannot be interfered with without injury to their life and growth. If insects devour the leaves, if fungi destroy the leaf tissue, if poisonous gases enter instead of air, containing a small proportion of carbon dioxide, then by so much are the life processes retarded or suppressed. If any of these abnormal conditions continue or reappear periodically, the effects become more and more marked, and in shrubs and trees the results may eventually be a slow and gradual death.

Between normal healthful conditions of environment on the one hand and abnormal unhealthful ones on the other, there are all grades and degrees. And in plants the current of life, although the same in kind, runs more slowly, ebbs and flows with less apparent effort and result than with animals. Hence, slight inharmonious surroundings may produce effects inappreciable except by delicate means of comparison and measurement.

Among the common evidences of unfavorable growth conditions are a weak and stunted growth, smaller size of leaves and twigs, and a lack of normal green color. When, from whatever cause, one or more of these conditions prevails in a given plant, it becomes thereby weakened, its power of resistance diminished and it may fall an easy prey to some secondary attack of insect, fungus or more obscure agent. Plant diseases and ailments are for the most part more difficult to determine than are those of animals, and they are correspondingly difficult to satisfactorily treat. Knowing then that

the ills to which plants are subject are legion, and hence their discrimination difficult, we may proceed to the question of the effects of noxious substances.

POISONS AND THEIR ACTION.

In the Soil. Solid substances, no matter how poisonous they may be, are entirely inert in their effect upon plant growth so long as they remain solid. Plants have no power to take in solid particles, no matter how minute they may be. Everything which enters and permeates the cell structure of plants must be either liquid or gaseous. But, inasmuch as soil constituents are always more or less subject to solution by percolating waters, it follows that poisonous solutions are not unfrequently present. Various alkaline substances, common salt and others, are those most frequently met with. Of such nature are the alkaline plains of some western States, many desert lands and sea coasts. These dissolved salts act directly upon the protoplasm of plant cells withdrawing its water, and causing it to become shrunken or coagulated. Strong solutions may act so quickly and energetically that death soon follows; but weak solutions may cause only temporary derangement, the protoplasm re-absorbing water and reviving if the solution is withdrawn. Long continuance of a weak solution, however, will often accomplish the same fatal result as the shorter application of the strong. In practice, cases of plant injury by poisonous substances, either solid or liquid, added to the earth are quite uncommon, and are limited to such natural districts as have been named, the immediate neighborhood of salt fields and vats and the waste and discharge grounds from some manufacturing operations, or occasional careless use of a lumpy chemical fertilizer.

In the Air. Noxious materials suspended in the atmosphere are, however, a frequent cause of injury to plants of all kinds. Inasmuch as the irritating agents here are often invisible and even inappreciable, except by delicate chemical tests, we are left to suspect, their presence and influence by certain appearances. These latter, as before stated, are so liable to be similar to such as are due to entirely different causes that special caution is necessary in distinguishing them.

The more visible and obvious air constituents are the soot and fine dust which, small in amount at any one time, sometimes by continuous production, become, at least, a very disagreeable accompaniment of the atmosphere and one which is naturally suspected of producing injury to vegetation. It settles upon leaves and stems, making a greasy or powdery film or incrustation which it would seem must interfere with the normal functions and activities of these

parts. Many are very familiar with the smutted coat which is imparted to every surface, plant or otherwise, in districts where bituminous coal is used. Even regions where other kinds of fuel are used are not entirely exempt from this annoyance, as closer observation will plainly show, but where large quantities of bituminous coal are consumed, there is where this particular factor is the most conspicuous.

To a small extent there is, occasionally, much inorganic dust from certain mechanical processes, but its general insoluble nature as well as limited quantity and distribution make it quite insignificant so far as plants are concerned. It was formerly thought that the stomata or leaf openings were so clogged by dust deposits that their natural action in water transpiration and in the ingress of air to the assimilating tissues was seriously interfered with. But more careful study has shown that there is little difficulty on this account. The construction and action of the leaf openings are such that they can be but little affected in this way. When marked injury follows, it comes directly from some chemical constituent of the deposit which is dissolved by the moist surface of the leaf and absorbed by its delicate cells. Should no such constituent be present, or should it be of such nature or quantity as to be neutralized, no injurious effects will follow. This has been fully proven by direct experiment. Burning benzine produces a dense black soot which is entirely harmless even to the fir trees, which are the most sensitive of all to a poisonous atmosphere. The practice of spraying, which has sprung up within recent years, has helped to solve these questions for us, since its effectiveness depends as much upon its not injuring the plant as in its ability to kill or prevent the development of the parasitic insect or fungus against which it has been employed. A properly proportioned spraying mixture must so neutralize the active poisons, should such be contained in it, that they are as so much dust, so far as the plant is concerned, or else they must be so weak as to cause no plant injury. Of the different invisible substances which may permeate the atmosphere of particular localities, it may be said, in general, that they are always more or less of a menace and injury to vegetation. The extent of that injury varies not only in accordance with the particular gas, its strength and abundance, but also with the kinds of plants, their distance from the source of the gas, and still further, according to the "lay of the land" and the meteorological surroundings. With all these factors bearing upon the problem, none of which are fixed, but which are as vagrant as the wind itself, it should not be surprising if so frequent attention is called to the liability to mistaken interpretation and to the general complexity involved. All injurious gases seem to act in the same general way, namely; to impair the integrity of such active

cells as they may reach. This they are able to do because of their superior attractive power for water which they abstract, and thus they interfere with the normal circulation and transpiration of those parts.

Protoplasm is of the most extreme delicacy and the slightest change in its composition reacts upon it unfavorably. Continued or intensified it soon produces serious, and at length, fatal results. Experimental laboratory proof of these phenomena in plants of simple structure have been repeatedly made and, so invariable are the fundamental laws of plant physiology, that the actions cannot be materially different in more highly organized plants. The effect of individual gases can best be considered by taking up, briefly, specific experimental cases and through them attempting to make the application to the localities where there seems reason to expect their presence.

Carbon Dioxide. This gas, so useful, even necessary, in the general economy of plant growth, as before noted, is, nevertheless, injurious whenever it occurs in more than the normal proportions. The effects are not as distinctive, however, as in the case of other gases, and the amount required to produce perceptible injury is relatively large. In practice, moreover, the cases where this gas alone may occur in sufficient quantity to injure vegetation, are exceedingly rare and local; hence we may pass them by.

Illuminating and Allied Gases. Illuminating gases of different kinds all exert a marked poisonous influence upon plants, whether applied directly to the leaves or permeating the soil and coming in contact with the roots. Small quantities in the atmosphere of a confined apartment, as of a room or greenhouse, slowly undermine the health of plants. The effects are shown in the early discoloring of leaves. With prolonged exposure or with more abundant gas, they may drop prematurely, or portions of the leaf, particularly the tips or margins, may die, becoming brown and brittle; sometimes the entire leaf will suddenly die, become dry and withered and hang tightly to the branch. Out of doors, a large quantity of gas or its continued flow for a considerable period, is necessary before the effects can be seen. Nevertheless, they occasionally occur in the neighborhood of natural gas wells and of city gas works. More frequent cases come from the escape of gas into the soil which it permeates slowly and extensively, gradually reaching the roots of many trees. Various examples of this the writer has personally seen and examined. One notable case occurred where two large maple trees of a row exceptionally vigorous were slowly killed by escaping gas from a broken pipe. The discoloring and premature dropping of leaves first called attention to the case. Examination then disclosed the earth charged with gas, the escape of which was traced

to a defective joint in the gas main. That such cases are not rare and may assume formidable proportions is shown by the following newspaper clipping, one of a number which could be cited.

"Trees on Our Streets Killed by Gas."

"The recent trial in the Superior Court resulting in the awarding of \$700 to a man for the killing of seven trees in front of his property by gas escaping from the street main, has called public attention to the destructive work going on in our own streets. The records of the city forester show that in the last three years more than twenty-five elm and maple trees on our public streets have been killed by escaping gas or the Holly steam heat. In addition to this record, there are a number of other trees that are nearly dead from the same cause, and it is expected that several will not leaf out this spring. The list of trees killed by gas during the last three years are as follows: One elm, Mulberry street; three maples and two elms, corner of Armory and Worthington streets; one maple, corner of Main and Union streets; two elms, near 431 Central street; three maples, Sargeant street; one maple, Fulton street; two elms, near 491 State street; one elm, near 63 Elliott street; one maple, Palmer avenue; four rock maples, Jefferson avenue; one maple, Bancroft street; one maple, near 119 North Main street; one maple, Oregon street.

"In addition to these, elms in front of the Unity Church were killed by steam suffocation, and a maple on Elliott street by a combination of gas and steam. City Forester Gale says that another elm on State street and other trees on Spring, Elliott and Mattoon streets are practically dead, and will probably have to be taken down this year. Other trees have been killed by escaping gas, including fruit and shade trees on private land, and, in some instances, claims have been made for compensation. In a few instances where trees have been poisoned by gas, the abutters have made sufficient protest to secure consent of the company to set out new trees. While in some of these cases there may have been other causes besides the one alleged (for street trees have a good deal to contend with), there is no reason to doubt but that the principal factor was the gas acting through the medium of the roots, since the proofs in such cases are and have been so easily applied."

Sulphurous Acid. The injurious gas most commonly found in the atmosphere and most widespread is sulphurous acid. Wherever combustion of coal or other fuels is taking place, there this acid in greater or less abundance may be found in the atmosphere. In case the fuel contains considerable sulphur or sulphur bearing minerals the amount may be relatively large, and where certain minerals rich

in sulphur are being used, and in some manufacturing operations, this acid is thrown off in such large amounts that its presence is easily distinguished by the smell and its effects may extend to long distances. The foliage of white pine trees has been affected and the trees gradually killed, seven miles away from certain works where copper ores were roasted in the open air, and no effort was being made either to recover the acid or to carry and diffuse it in the upper air by a tall chimney. Inasmuch as nearly all coal contains some sulphur in one form or another, and coal is so widely, and in such large quantities, used in Pennsylvania for fuel, coke making and the like, it is evident that sulphurous acid is liable to be widely diffused, and it would be expected to have some deleterious effect upon the atmosphere. Many experiments have been made with this substance in order to determine its influence upon plant growth, and it has been found that in closely confined situations, as under a bell jar or in a green house, so minute quantities of sulphurous acid as one millionth of the atmosphere exert a fatal injury upon young fir trees after a continuous exposure of about sixty days; while for beech and maple trees one ten-thousandth produced the same result. Potatoes, clover, oats and various grasses became withered and browned after twice having a two hours' exposure to an atmosphere one forty-thousandth of the volume of which was made up of this acid, or after fifteen to twenty exposures of two hours each to an atmosphere one sixty-thousandth of sulphurous acid. These are very minute proportions of the poisonous agent, but the plants being continuously bathed in it for the periods indicated they were compelled to use the noxious air by reason of the confined situation in which they were growing. In the free open air it is only in occasional situations that any plant could be subjected to such constant exposure to sulphurous acid. Generally, either by variation in the amount of acid, the condition of the atmosphere, the direction of the wind, or other meteorological conditions, the supply of the poison is more or less intermittent. Hence, the results are mixed and the effect of a highly vitiated air may be slight because of its short duration; on the other hand, that of an atmosphere so slightly contaminated as to attract no attention may, because of its long and steady continuance, slowly produce the characteristic leaf marks which are the first visible effects of poisoning. The action, as before noted, consists in disorganizing the normal water movements of the leaves and green tissues. Hence it may be quite similar in its effects to that of various other agencies. The most delicate parts of the leaf, such as the tips and margins, are generally the first to show injury, and oftentimes no other portions are involved, owing to the weakness of the poisonous gas or its short continuance.

In this stage, particularly, it is impossible to absolutely distinguish between the effects of the poison and those of drought or sunburning, for instance; they are to the eye substantially the same. But here chemical analysis may be brought in to decide the question. Leaves injured by sulphurous acid will show a larger quantity of sulphur (generally determined as sulphuric acid, SO_2), than normal leaves or those injured by other means. Quoting from the authors before mentioned, there were found in 1,000 parts of water free leaf substance the following quantities of sulphuric acid:

	Sound plants.	Affected plants.	Difference.
Beans,	6.119	6.561	.442
Buckwheat,	5.175	5.880	.705
Grass,	7.105	8.336	1.231
Rye,	3.684	5.610	1.926
Wheat,	2.179	4.412	2.233
Oats,	2.926	6.783	3.857
Potatoes,	13.000	17.500	4.500
Plum tree bark and young twigs,	1.23	2.43	1.20
Fir tree twigs, .....	.99	2.48	1.49
Pine tree leaves,	2.40	7.54	5.14

While it is true that a given species of plant will, when growing in different soils, take up different amounts of mineral substances quite independently of the atmosphere, the range of variation is much less than this table shows, and the absolute amounts of sulphur (estimated as sulphuric acid), never so great as is found in the column for affected plants.

The table shows, moreover, that there is considerable difference in the susceptibility of different species of plants. Assuming that they are equally exposed, some species are more quickly affected than others, as some are found on analysis to have taken in greater quantities of the poison. To some extent this may be determined by the condition and vigor of the individual plant rather than upon its species; and yet, it is not entirely clear what that relation is, nor how it operates. It was formerly supposed that the acid was taken into the leaf through the breathing pores or stomata only, which are, as a general rule, more abundant upon the under side and indeed are often confined to that side. But it has been found that it may be taken in through any part of the leaf although that which enters through the stomata more quickly and more effectively reaches the active cells and saps their vitality. Besides, it would be a mistake to suppose that injury is directly proportioned to the number of stomata, since it is found that there is no uniform relationship between the two. Among forest trees the narrow leaved evergreens,

the cone bearing trees, pine, spruce, etc., are more seriously affected than the deciduous leaved, oak, hickory, etc., although the last mentioned take up in a given time more sulphurous acid. But the leaves of evergreens, while less permeable, last not only through the growing season, but through the winter also, and even on one occasion, several consecutive years, and hence there is an accumulation of the poisonous ingredient and a cumulative effect from which the deciduous or annual-leaved trees are practically exempt. The case of differences in the susceptibility of fruit trees is not so clear, although the general results seem to show that the stone fruits, plum and cherry, are somewhat more quickly and easily affected than the pomaceous, apple and pear. But the difference is not marked, and perhaps not uniform, being determined more by the condition of the tree than the kind. Similarly with garden and field crops of cultivation the results are somewhat contradictory, so that we may conclude that there is not a marked difference between varieties; or, that as a practical question, it has little significance, since conditions of exposure are themselves so seldom identical. It is a fair inference, however, that injury is in direct ratio of the vitiation of the atmosphere. Since gaseous poisons are with time and distance diffused and diluted so as at length to become indeterminable, even by chemical means, it follows that injury is in inverse ratio to distance from their source, or the greatest injury may be expected near the source of the gas or smoke and it will diminish as one moves away from it. The following illustrates this:

Amounts of SO_2 in oak and white pine in the neighborhood of a zinc blende furnace. The distance may be assumed to be that which could be easily covered by walking in the times named.

	25 Minutes.	45 Minutes.	75 Minutes.
Leaves, oak,	8.26	5.60	4.92
Young twigs, oak,	2.85	2.44	2.48
Leaves, pine,	6.98	5.46	3.89
Young twigs, pine,	2.48	2.48	1.94

Exceptions to this general law are sometimes found where the source of contamination is in a narrow depression or ravine, as very commonly occurs in mountainous districts. There the rising smoke or vapors may so quickly mount to the upper levels that the near neighborhood is passed by almost uninjured while they more slowly drift over and bathe the vegetation of the tops of the ridges and adjacent lands. The plainest and most positive cases in European experience are of this kind—plain and positive because they

are in mountainous regions devoted to forestry and not to cultivation, and the cumulative effect of smoke and vapor injury can only be obtained in forest or orchard districts.

Wind direction is likewise an important factor. Every locality has its prevailing wind direction and wherever there are conspicuous centres of sulphurous acid production the degree of injury to adjacent vegetation corresponds pretty accurately with that direction. The leeward side receives the bulk of the poisoned air, while the windward, being measurably free from its influence, is conspicuous by the better character of its plant, especially of its tree growth. This, however, is much complicated with the "lay of the land," as well as with other meteorological conditions. So evident must this be to the attentive reader that further consideration of it is unnecessary at this point, excepting so far as to note that much depends upon the dryness or moisture of the atmosphere. A moderate amount of moisture, particularly in the form of dew or as mist or fog in the air enveloping leafy trees, is very favorable to the retention of sulphurous acid, and tends to intensify its effects upon plants where it finds lodgment. The effects of sulphuric acid, should that particular compound be produced, are substantially the same. Only in cases where insoluble sulphates are formed, would the poisonous actions cease. Upon the activity of the plants seems to depend the avidity with which they absorb.

Hence during the day, when stimulated by light and the transpiration and assimilation of plants are greatest, the poisonous gases would be most injurious. At once it can be seen that here are factors which often do not act in conjunction, since the moisture is the more frequently present during the night time, when the activities of the plant are the least. As a general rule, it has been found that plants are much more subject to injury during the day than during the night; but it has exceptions.

It should be noted in these explanations that no account is taken of injury to parts other than the leaves and young twigs, and, in the consideration of gases in the earth, of the roots of plants. There is no evidence that these poisons extend to any considerable distance from the places of entrance, and, indeed, from the view point of effect, there is no need that they should extend any further. They do their work quickly and effectively where the plant's work of food taking and preparation are going on, and more or less interfering with that they thereby cut off the food supply and thus limit increase and future growth. Trees thereby not only lose their leaves more or less, depending upon the severity of their attack, but their growth in every direction is impaired, since there is no more positively proven fact than that the leaves are the agents directly concerned in preparing the materials of growth. Hence anything which

interferes with the leaves is registered by reduction in the increase of some part of the plant. This is quite plain as respects the yearly layer of wood in tree trunks. In the German forest districts where these matters have been carefully observed and studied, the neighborhood of various smelting and other furnaces has reduced the normal increase in the thickness of the ring of yearly growth in tree trunks, as well as had its more rapid effect upon annual vegetation. Perhaps no more striking cases of the injury of plants from noxious vapors can be cited than those frequently referred to in horticultural annals as having come from the use of coal tar painted pipes in greenhouses. So common is it for ordinary purposes to use a coal tar paint to prevent the rusting of iron pipes, that through ignorance or inadvertence the pipes used for greenhouse heating are sometimes so coated. The results are uniformly injurious to the plants under cultivation and often disastrous. The comparatively small surface of these pipes and the small amount of material used to coat them gives one a very good idea of the danger of even slight contamination of the air in a confined situation. That which saves out of doors vegetation is the extreme dilution which poisoned air quickly acquires when there are no confining walls. A single illustration from the large number at hand will serve to emphasize this point.

"Danger from Coal Tar.—By Peter Henderson, Jersey City."

'We have recently put new water pipes into our greenhouses, and, unfortunately had them painted with coal tar, very much to the injury of our plants. Can you suggest any remedy to get rid of the trouble, or will the gas discontinue after awhile? J. D. C.'

"The above is one of three letters received during the past thirty days from parties who have been unfortunate enough to have painted their hot water pipes with coal tar, asking what to do to get rid of it; and though I have replied by letter to each, there is but little doubt that others will fall into the same error. I thought it would be well once again to give warning through the Monthly, and at the same time state what is believed to be the only remedy when the mischief is done—namely, to take down the pipes and burn them in a heat sufficient to evaporate the tar which penetrates deep into the iron. This can only be safely done at this season, of course, by providing some temporary means of heating, such as stoves, until the pipes can be again put up; but it is better to go to that expense and inconvenience at once than to keep firing during the whole season with the tar-painted pipes. For every cold night when extra heat is necessary, will show the evil results in the morning by showers of dropping leaves and flowers. In your columns again and again has

the warning against painting hot water pipes with coal tar been given, yet every season brings its fresh victims, * * * As the substance is a dangerous one, whenever exposed to a temperature high enough to evolve the gas, we have come to the conclusion that it is safer to keep it from the inside of the greenhouse altogether."—Gardener's Monthly, Vol. XXIII, p. 75.

The coating of greenhouse benches with coal tar paints with a view of adding to their durability likewise acts unfavorably upon plants through the medium of their roots. The ordinary covering of earth in which plants are set is soon penetrated by the growing roots, and as soon as they come in contact with the tarred surface of the bench they show signs of distress to be followed by discolored and falling leaves. Serious injury has likewise been done to young peach and other fruit trees by the use of coal tar and similar substances upon their trunks as a preventive of insect attack. While upon dead and flaky bark of an old trunk no injury whatever is occasioned, the more delicate living bark of the sapling quickly absorbs and is thereby injured, even fatally. Experience has shown that in the use of hydrocyanic gas and bisulphide of carbon in fumigating nursery stock, grain, seeds, etc., there must be careful regulation both as to the intensity and the length of exposure, lest not only the parasite be killed, but the host plant also.

From local and limited cases of this nature to the more general and larger examples met with in outdoor life the passage is not so abrupt as may at first appear. The main difference is the almost infinite dilution which gaseous substances undergo, particularly when by tall stacks or chimneys they are delivered a hundred or more feet above the earth and are projected and diffused by forced draft. In these last mentioned cases, only gases of the most acrid nature, when produced almost continuously and in relatively large quantities, are liable to have any immediately perceptible and recognizable effect upon vegetation. Much depends, however, upon atmospheric conditions, proximity of plant growth and the like; and a conjunction of circumstances may occur which will produce marked destruction of foliage in a few hours time. An example of this latter nature came to the notice of the writer a few years ago. On the third of July the neighborhood of the large chemical manufacturing plant at Natrona was visited. Some three weeks before that date the evidence of injury by gases was said to have been very marked, but at this time they were not indisputable. It was not easy to discriminate between injury by gases and possible injury from other causes. The general appearance was of repair of vegetation due to the early time of the year, the height of the growing season, when new growth pushes out vigorously and rapidly in its effort to take the place of that which has been lost.

The same locality, however, was visited on the eighth of September following. At this time the leaf destruction was most evident and undoubted. It could not possibly be confused with that from any other cause—insect, fungus or frost. The course of a fire could not have been traced with greater ease and certainty. Indeed, one not knowing the neighborhood would have thought of fire as being the only agent capable of producing such a result. But the tell-tale fumes from the tall stack, although delivered 260 feet above the surface, had been visible for several days and their odor in the atmosphere was at times quite plain. The “fire” was the acids which had permeated the air in such strength that they burned the leaves as effectually as if a scorching flame had swept over them. This case is evidently an extreme one and also local. Few manufacturing operations are attended with the expulsion or escape of such large quantities of destructive acids. Generally, even where they are the same chemically, they are of such extreme dilution or so variable in quantity, that, under the most favorable conditions, their effects are not marked or distinguishable. They are best seen, perhaps, upon metallic substances, such as wire, nails, iron roofing and the like, or upon such easily decomposed materials as marble or limestone. Slow oxidation occurs in any atmosphere, but, when reinforced by abundant moisture, and particularly by acids, it may become a destructive agent of no mean power. It is a matter of common and in general correct observation that exposed iron rusts and thus deteriorates with unusual rapidity in the neighborhood of large manufacturing operations owing to the smoke and fumes which are so abundantly poured out even though they may come from fuel combustion only. Marble monuments, likewise, more quickly lose their lustrous polished surface, due to the granulation caused by chemical decomposition. In the opinion of marble workers, such are the differences in the atmosphere that the wear is at least six times as rapid in the manufacturing districts of Pennsylvania as in the agricultural. The difference between a granite and a marble surface under such exposure is very marked. The more durable granite surface resists corrosion a much longer time.

These instances are cited as illustrating the general contamination of the atmosphere from manufacturing operations. It is a reasonable inference that by so much the atmosphere is unfitted for the respiration of animals and plants, although we may have no definite proof of the same excepting where the contamination rises above a certain not very well established degree. Theoretically, every fire, no matter how small or of what material, contaminates the air and renders respiration more difficult. Practically, this is immaterial until such contamination becomes visibly apparent or determinable by chemical tests of its results. Setting aside the cases of certain

special operations, such as that of the chemical works above referred to, large iron furnaces and the like, the combustion of coal is the chief cause of atmospheric contamination. Wherever this occurs in large quantities the air becomes charged with different injurious substances, the amount of which depends upon the quality of the coal as well as upon its quantity; poor coals or those containing much sulphur often give rise to disproportionally large amounts of injurious gases. Primarily, the dense black soot which makes the visible part of coal smoke is a source of much annoyance, if not of positive injury. This is a matter of common observation and remark. People who have all their lives lived exposed to it have become so adjusted to the conditions that they expect nothing else and may even affect to make light of it; while others not so accustomed wonder how it can be endured. It settles upon everything for miles around and by its fineness and long suspension penetrates the minutest crevices. Farm crops are as though attacked by smut, and the delicate white satiny petals of many flowers, particularly those from spring bulbs, are useless after a few hours of exposure. Disagreeable as this may be, the evidence all goes to show that no injury to the life and growth of plants would be occasioned were it not for the sulphurous and other acids for which the soot is a vehicle or carrier; that the soot as dust is practically inefficient in retarding or injuring vegetation. Only in so far as it carries poisonous substances and serves as the medium to distribute them is it a source of injury. It follows, then, that much depends upon the purity of coal and the completeness of its combustion. In the strife for reducing the expense in various manufacturing operations, neither of these points are given sufficient consideration. Smoke consuming devices are not used so generally as they should be, and the nature and method of the discharge of wastes receive but scant attention, except as they directly concern the economy of the manufacturer himself. The atmosphere, particularly, is looked upon as a common dumping ground and receptacle of all floating rubbish. What becomes of it there seems nobody's business.

In many localities in Pennsylvania are large districts devoted to the production of coke. In them large quantities of coal periodically undergo an incomplete combustion whereby the volatile matters are consumed or expelled, leaving as a residue the commercial coke. The methods employed in this process in this State are generally of the most primitive and wasteful character, since on an average, fully one-third of the coal is lost, a considerable part of which is added to the air as a poisonous element. So disagreeable and destructive are these fumes that the immediate neighborhood of the coke ovens is, by common consent, useless for any other purposes,

and should trees or cultivated crops be within range of a few rods they soon show plain signs of distress. Trees may often make a brave fight even for many years before they finally succumb; but the result is inevitable. With annual crops the case is somewhat different and the results must needs vary widely with circumstances. Should the fumes stream somewhat steadily over them for a moderate time only it will prove disastrous; on the other hand, slight or occasional bathing in the vitiated air may have so little effect that it is indistinguishable, the plants growing with such rapidity as to appear to suffer no injury, but a small dose of poisoning just at the time of flowering sensibly reduces a crop of grain both in quality and quantity although it may not show in the forage. The intermittent character of the process of coke making, moreover, introduces another element which tends to complicate results and make the use of exact figures and strict statements altogether impossible. Where a number of ranges of coke ovens are interspersed somewhat closely together, the district becomes almost continually one of a highly vitiated air, seldom without the overhanging clouds of smoke and a most unfavorable and unpromising field for vegetation of any kind. That the effects are not more marked is also due, in a measure, to the brief period during which annual crops are exposed, and the limited number of either fruit or forest trees which are left in such localities. Regarding the former the three or four months of their life may be, and oftentimes are, the months when the works are in minimum of operation, or, when they are in part shut down for repairs; reasons for immunity or little injury fully as likely to prevail as any before named. Regarding the latter, the most conspicuous feature in coke oven surroundings is the general wretchedness of everything of the nature of shrub or tree, either individual or collective. As if the smoke were not enough to contend with, they become the natural prey of vagrant animals, are cut and hacked indiscriminately by troops of idle boys, or are obliged to serve as the target for the attack of innumerable picnickers—treatment which might well cause any self-respecting tree to wish that it had never been born. Agriculture, moreover, is in such surroundings very apt to languish on, what may be called, general principles. Mining and manufacturing have largely supplanted it. Orchards and woodlands are not maintained. They are allowed to fall into decay as being less profitable than formerly or offering too uncertain returns to warrant their continuance. Hence trees of different kinds, which, for various reasons, as before mentioned, are the best index of air pollution, are so few or so uncertain that but little more than has been stated can be learned from them. That there is a slow and progressive deterioration going on in them from this cause can

scarcely be doubted. Clearly is this the case near by, less plainly as the distance increases until gradually all signs are lost and the distance limit could only be determined by a careful and prolonged series of chemical determinations, by which might be established an approximate line or rather band, on one side of which analyses showed an excess of smoke derived constituents, on the other the normal contents only. Presumably the former district is directly injured by the atmosphere, the latter not. To attempt to dogmatically fix such a line in any other way would be most rash and unwarranted.

FIELD OBSERVATIONS.

The writer was charged with the task of attempting to determine how far, if at all, the agricultural and forestry interests of Pennsylvania are injured or menaced by pollution of the atmosphere in coke and other manufacturing operations. Some attempt was made through a circular letter to find localities in which injury was suspected or known. But few of these inquiries received any answer, and such replies as were received were almost entirely of a general character alleging injury but unable to fix it with any definiteness or certainty. This indefiniteness, even vagueness at times, should occasion no surprise. It is, as there has already been occasion to note, no more than could be expected from the circumstances of the case, and yet no one can travel through some parts of our State without feeling that there is, at least, strong ground for suspicion that one cause of injury to vegetation is the pernicious atmosphere from which plants are compelled to draw their food. Bituminous coal is so largely used for fuel and coke making in the western part of the State, that this is the only portion which the writer has visited. The most attention was given to the neighborhood of Mt. Pleasant, although some time was spent in the vicinity of Latrobe and Uniontown. Shorter visits were made to several other places and facts were gleaned from every available source.

In going from the central part of the State, a generally agricultural and non-manufacturing region, to these localities just named, the contrast in tree growth, particularly, is certainly very marked. The large number of dead and declining trees and the frequent pinched and defective leaves of the trees are in sharp contrast to the more vigorous and healthy foliage of the former district, while the smutted look and touch almost universal throughout the bituminous regions make an additional feature as disagreeable as it is common. The thinness of leafage and the lack of large trees showing normal vigor seem an inseparable accompaniment of the great mining and manufacturing localities.



No. 1.—Showing the almost total destruction in the immediate neighborhood of the chemical works, Natrona. The tall stack (250 feet) is of recent construction.



No. 2.—Ravine close to the chemical works, Natrona. Many dead trees have been removed.

Striking as this is to the eye, it would be unfair to draw conclusions from it alone. In the first place, the kinds of trees differ considerably in the two districts. The west has as native trees almost none of the conifers which are so conspicuous east of the Alleghenies and give such a decided face to the landscape, and has more, relatively, of the oaks, hickories and locusts.

Moreover, the districts under consideration have, relatively, little forest tree growth apart from the distinctively mountain ridges. Woodlands are found chiefly in patches of a few acres only, scattered among the cultivated lands or as borders and fringes to streams and hillsides. Still further, the energy and industry of the people are so taken up with the more promising, because more immediately profitable, manufacturing enterprises, that little care and attention are given to the agricultural—least of all to anything which can be dignified by the name of forest care. The woods of use for construction purposes have been largely removed years ago, and such as are now needed are more easily drawn from other localities because of the cheapness of transportation. Hence, there is little incentive to conserving, still less to increasing, the supply. Even for fuel purposes wood has almost no value, so cheap, abundant and available is the supply of coal. What wonder, then, that forest tree growth should receive almost no care and attention, and be limited to such farm lots, hills and ridges as have not seemed needed for cultivation. Here it exists by sufferance only. Should local conditions warrant, this may be at long intervals culled out in the haphazard, unscientific and unprofitable way, so characteristic of our methods; for the differences in method are after all only those of degree and not of kind; other parts of the State show the same general peculiarities. It is astonishing how much of this timber apparently good is defective because of its age. Dead crowns are exceedingly common and few large trees are without more or less dead branches. Where cutting has recently taken place, whole trunks are often so rotted as to be useless and the refuse left by the portable saw mill suggests the work of a tornado rather than a serious attempt to utilize the forest product. In respect of fruit trees and fruit cultivation the case is not materially different. In spite of the apparently heavy demand for fruit consequent upon a large population of consumers, their wants are largely supplied by importation and the home production is surprisingly small. It is not to be supposed that this is universal. Here and there are men acute and long-headed enough to profit by these conditions, and whose well-kept orchards and careful management stand out in sharp contrast to their neighbors. But the district, as a whole, shows the same neglect and even decay of its orcharding as of its forest capabilities. Hence, its fruit trees illustrate the same phenomena, namely: Many

orchards past their prime, unpruned, uncared for, in varying degrees of decrepitude; and the query naturally arises, why? In large part from pure neglect, because of the economic reasons stated; in some measure, for other reasons.

To the oft-repeated complaint that we have fallen on evil days, and that the smoke and soot, the fumes and gases are at the bottom of the whole matter, a deaf ear ought not to be turned. Taking the facts as they now stand, it should be noted that but little reliance should be placed upon the appearance of individual trees—still less of isolated trees. The latter are almost always at a special disadvantage. Deprived of the association of their fellows in which there is an undoubted element of strength for physiological (not from sentimental) reasons, they are the target for a host of enemies, and unless most favorably situated in a deep and well-protected soil, they gradually fail in vigor and ultimately disappear long before their normal age has been attained. The greater exposure to wind and air calls for special strength to withstand wind strains and also makes heavier drains upon the water supply, while injuries to the roots due to injudicious cultivation or the dense matted grass which may take the place of other undergrowth may make that supply more precarious. Insects and fungi are more liable to attack them, and are more persistent, particularly where branches or bark have been broken. One or more of these factors may suddenly appear for no obvious reason, and yet a careful analysis may disclose it. For instance, florists understand that their potted plants will often drop their leaves from excessive watering. Singularly, perhaps, drouth may produce substantially the same result. Contradictory as this may appear, it is physiologically explicable. Both conditions react unfavorably upon the protoplasm which is the seat of cell activity, and the plant seeks to adjust itself to the new conditions by reducing its transpiring surface. In the instances cited it is done suddenly, at an apparent sacrifice of some materials which might be removed and utilized elsewhere; in other cases, the need perhaps being less imperative, there is a slow change whereby the leaves become first, slightly discolored as cell contents are changed and removed, later, they hang limp and yellow, finally falling one by one as in autumn. Both of these phenomena may be seen in many fruit and shade trees and the correlation to the weather changes proven.

But a decided wet or dry period is not absolutely necessary. Such seems to be the initial vigor with which some trees start out in the spring of the year that they miscalculate, as it were, their abilities and their necessities, and suddenly, like a ship shortening sail, they must needs drop some of their leaves or part with them by the slower process. The Norway maple is particularly subject to the former, and the cultivated cherries, both Morellos and Maz-



No. 8.—Apple orchard at Mt. Pleasant 35-37 years old. Was carefully pruned two years ago. Extensive coke works $\frac{3}{4}$ mile west.



No. 4.—Young apple tree, thin-leaved, suffering from no obvious cause except periodical exposure to the fumes from the chemical works. Natrona.

zards, to the latter. Equally surprising and puzzling to the casual observer is the sudden drying of a part or sometimes the whole leaf with no tendency to fall. This sometimes occurs during midsummer but often comes earlier. Special caution should be observed here since many of these cases are plainly due to minute insects whose larvae "mine" the leaf, slowly eating out the central mass of leaf substance, and leaving the skin intact as a loose filmy membrane. The white oaks and locusts have been so affected this year to an alarming extent. But the same physiological cause as just instanced, that of loss of water, is in frequent operation. The sugar or rock maple is the native species especially liable to this latter and to some extent shows its marks every summer. But so many cases have occurred this year that it has occasioned much comment and curious speculation. Entire trees have been stricken and, what at first may seem inexplicable, is that intermingled with them may be some which are not affected but are in every respect perfectly normal. Nevertheless, the same explanation holds. Prolonged hot sun or drying winds rob the leaf of its moisture. The tree is unable to make good such heavy drain, and collapse is inevitable. Why one tree suffers and not another, some leaves and not others of the same twig, some parts only of a given leaf and not other parts—all are due simply to individual differences in condition; the weakest go first. Sometimes, but not always, given trees show beforehand that they are unable to bear such a drain should they be called upon to do so. They are in a thin soil, or root-bound, or have been injured.

A tree which the writer has made note of for several years, uniformly produces normal foliage, but about midsummer a single branch only suffers the drying of a part of its leaves—all due to a wound upon the trunk which permits of sufficient sap flow for a time, but later, when the needs of the leaves are greater, they cannot be supplied.

The following cases, taken from a number on record, will serve to show how common and widespread is this phenomenon.

NORWAY MAPLES INJURED BY DRY WIND.

About May 25th, 1895, the Norway maples (*Acer platanoides*), on Long Island presented an appearance which puzzled observant persons. The entire foliage even of large trees looked as if it had been scorched by fire or killed by heavy frost. But since there had been no frost for at least three weeks the phenomenon was at first thought inexplicable. However, the fact that the trouble was a general one and appeared suddenly suggested the idea that some unusual condition of the weather was responsible for it. Such was in fact the case. For a period of about a week previous to the appearance of

the trouble the temperature had been unusually high for the time of year, and for at least three days very strong dry winds had blown steadily from the west. The leaves of the Norway maples were about half grown at this time and very tender. The hot, dry wind caused the leaves to transpire water more rapidly than the roots could supply it, the consequence of which was the death of the leaves. It was observed that some trees suffered more than others and trees recently transplanted were burned most severely of all. The explanation of this is that trees in sheltered positions transpired less water, and consequently suffered less than trees exposed to the wind; and trees newly transplanted were not able to supply their leaves with water as rapidly as were trees with well established root systems. The common practice of horticulturists in pruning away large portions of the tops of plants, especially conifers, at the time of transplantation, is based upon the same principle, the object being to reduce the transpiring surface to the minimum until the plant can establish a root system.

15th Am. Rep. N. Y. State Exp. St., p. 453.

"Last May a number of maple leaves in a dry and crispy condition were sent to this department from various parts of the State under the supposition that they were affected by some form of fungous or insect life. Examination of the leaves, however, showed that no form of either of these organisms could be found. All of the leaves that were sent in were those of the sugar maple (*Acer saccharinum*), although the same condition was observed in a large number of different varieties of Japanese maples growing on the College grounds. Moreover, they showed the wilt only on one side of the tree, namely, the west, that being the direction of the prevailing wind the day upon which they were affected; and this peculiarity, so far as could be learned, was the same all over the State. This phenomenon is especially interesting, as it occurs on apparently healthy trees under certain exceedingly unusual conditions—conditions, too, which, lasting only a few hours, are yet capable of giving rise to abnormalities of function. We attribute the wilting of sugar maple leaves, which occurred quite generally throughout Massachusetts on May 18th, to an excessive transpiration or evaporation of water from the leaves, at a time when the water supply of the roots was extremely limited. This was brought about by a remarkable combination of meteorological conditions favorable to this result. It is well known to vegetable physiologists that agitation of the leaves of a plant greatly accelerates the process of transpiration—that is to say, the evaporation of water from the leaves. It is also well known that transpiration is accelerated by light, a low relative humidity and a high temperature. Such were just the

conditions upon May 18th. During the months of April and May the rainfall was far below the normal, while the long continued drouths of the two preceding years will be well remembered. Thus it is evident that the supply of water available to vegetation must have been much less than usual, and under the unusually strong, dry and warm wind of May 18th, the leaves of a tree like the maple with its large surface might be expected to become greatly exhausted and wilt badly. When this wilting was not carried to excess the leaves recovered; when, however, it went too far it resulted in a dying and subsequent shriveling of the foliage. Another factor which must not be overlooked in accounting for this disorder, is the maturity of the foliage. Young leaves always give off the greatest amount of water and the maple leaves in May are giving off their maximum quantity. With plenty of water in the soil these high winds would not have caused any wilting; or if the same conditions had ensued during August or September when the foliage was more mature, less wilting would have resulted. The west side of the trees being the side exposed to the prevailing winds was the most seriously affected. This opinion seems confirmed by the peculiar meteorological conditions which are appended, showing that the rainfall from May 1st to 18th was only .16 of an inch; that on May 18th the maximum wind velocity was 71 miles an hour, the temperature 84 degrees, the relative humidity 47.31, and the number of hours of sunshine 13, in a possible 14½—a combination of conditions that, were they continued for more than a few hours, would doubtless wither the foliage of all vegetation.”—9th ‘Am. Rep. Mass. (Hatch) Exp. St., p. 81.

Among annual plants the common potato likewise often illustrates the whole phenomenon remarkably well. It starts out in the spring with great vigor and quickly develops a relatively large and luxuriant growth of “tops.” When the hot and dry weather comes on the tips and margins of the leaves begin to “burn;” they become dry and dead. Whole leaves, whole branches, perhaps the entire “top,” may more or less rapidly die from sheer water waste. The root system of the potato is proportionally small and weak. It cannot stand the fierce heat of our climate and succumbs early. Here and there plants better rooted or in some way protected or favored resist the change for a longer time and may stand out for a while in sharp contrast to the large body. This is entirely independent of the loss of leaves from fungous or insect attack, both of which are exceedingly common, and hence, necessarily complicated with it. Insect work is generally perfectly plain and easily distinguished, but the so-called “blights” of the potato are easily confounded with this death from drying out.

There yet remains the consideration of "blighted" leaves, by which is generally meant such as have been attacked by fungi, for the most part so minute and so insidious in their life history that only the professional botanist can detect their presence. There is less difficulty with them, however, than would at first appear, since they seldom attack plants as a whole or involve the entire leaf or destroy more than minor portions. Often the infected areas are so small as to produce only small circular spots, although these may sometimes run together along the main ribs or margins of the leaf and thus obscure the cause. Fungi, too, may affect the bark as well and are a frequent cause of the general lack of vigor, the gnarled appearance of branches and the diminished size and crumpling of leaves. They are to be looked for in fact wherever the higher plants occur, either as causes or accompaniments of any diseased condition; only careful and patient study can detect which. The reader should thus carry with him some conception of the host of plant ailments and the fact that they must necessarily become to the eye so interwoven and entangled that separation and proper determination of the exact cause in each case calls for the knowledge and acuteness of the skilled physician who diagnoses his patient's case by a careful collation and comparison of his symptoms. Among the plant ailments, that which is due to a poisonous atmosphere does sometimes take place. The evidences are in the drying and death of the tips and margins of the leaves or in their discoloration, features so similar to that from drouth, as just narrated, that special care and further observation are necessary in the discrimination. While some plants are more subject to injury from the atmosphere than are others, nearly all kinds should, after a little time, show approximately the same results, unless the vitiation of the air is slight or quite intermittent. As a matter of fact, one passing through the districts under consideration would see (except in the near neighborhood of coke ovens or other establishments), but little of this direct evidence, and none from which alone he would be warranted in forming positive conclusions. There would be much which would appear attributable to polluted air, but to be positive that this is even one of a number of causes he must bring to his aid chemical analysis. For instance, specimens of white oak leaves gathered near Mt. Pleasant, in a small wood lot on the leeward side of a large range of coke ovens and about three-fourths of a mile distant, gave, on crumpling them, a distinct and positive smutting to the hands and showed slightly the marginal browning and dying. On analysis they gave 3.6 parts of sulphuric acid per 1,000, water-free substance, while similar leaves from a white oak at State College gave no coloring on handling and 1.9 parts of sulphuric acid. Still more marked is the difference shown in apple leaves. These

were in both cases a little further away from the nearest source of contamination; that at Mt. Pleasant being the coke ovens and iron furnaces only, and that at Natrona the chemical works.

Water-Free Subs.

	SO ₂ in 1,000 pts.	Chlorine in 1,000 pts.
Mt. Pleasant,	12.3	2.7
Natrona,	6.4	2.6
State College,	1.7	Trace.

None of these trees had received any chemical or special fertilizing of any kind, nor had they ever been sprayed with chemical solutions used for insect or fungous destruction. Hence it is a fair inference that the abnormal composition came from the air supply, since such large proportions of these constituents are not possible from any other source. These trees were not very plainly or conspicuously suffering; they were young, making fair growth, but beginning to show suspiciously curled and early browning leaves. If, year after year, the injury should be continued they would be weakened and give way prematurely, as apparently had older trees in their vicinity. This matter of tell-tale chemical analysis which is, it should be noted, the final and essential proof the writer did not attempt to carry further, since it would involve so large an amount of work and, as before stated, it has been so fully and completely done elsewhere, and, moreover, injury is almost self-evident in the near vicinity of the source, but grades off insensibly as one departs from it. Our practical question is, are poisoned air effects on vegetation so evident at moderate or considerable distances that they are a definite injury? A prolonged and exhaustive series of chemical analyses would doubtless throw some light upon this point, but their value would be scientific, rather than practical, since so variable are the conditions that it would scarcely be possible to establish a definite and unvarying line applicable to all localities and surroundings.

As a practical and general rule it would appear that wherever the foliage of the season is distinctly smutted, and by crumpling it the hand becomes plainly blackened, there some injury is being done, and should the condition continue year after year it may prove a most serious factor in plant growth. This opinion is founded upon the fact that although there is no real injury from the dust-like nature of the smut acting to choke as by mechanical means, as has been thought, it, nevertheless, carries gaseous and soluble particles

which through moisture are imbibed and produce the poisonous effects. This, regarded as a somewhat flexible rule, would include as injured territory a considerable acreage in the neighborhood of all coke ovens and some manufacturing plants, and would extend in some cases to the forested slopes of Chestnut Ridge in Fayette and Westmoreland counties. So far as annual crops are concerned injurious effects might be seldom distinguishable, simply because of the short period and the irregularities of exposure. While trees, compelled to register the varying effects of year after year, would be expected to be poorer developed, unreliable and shorter lived than their fellows growing under salubrious conditions. The fact that evergreens, the trees most sensitive to a vitiated atmosphere, are practically wanting in the districts named, while the oaks, the most resistant of trees, make up the bulk of the growth, renders the proof of this rule less easy to establish than would otherwise be the case. No fact, however, is better known to horticulturists than that evergreens, both of the narrow leaved and broad leaved types, are exceedingly unsatisfactory in ornamental planting throughout the bituminous region of our State. They notoriously fail, become weak foliaged, thin and scrawny in a few years after planting, and healthy specimens of middle age are almost unknown. It can scarcely be doubted that artificial planting of the white pine for forestry purposes anywhere within the range under consideration would result most unsatisfactorily; on the other hand, the very fact that so large proportions of the existing woodlands are of oak makes the injury not only less easily observed but absolutely less in amount. Speaking generally, then, it would appear that there is a certain injury and a certain constant liability to injury to vegetation from smoke and gas, but that both are quite irregular and spasmodic in their effects, and that outside of the near neighborhood of their production they are with difficulty traceable or separable from other inharmonious conditions.

Unsatisfactory as so general a conclusion as this may be, it is difficult to see how it can be made any more precise or specific. The practical working conclusions which may be derived from it are that wherever smoke and gas waste are in quantity thrown into the air, there the circle of non-cultivation should be made a liberal one and that some distance outside of this begins the zone of practicable tree growth.

SUPPLEMENTARY CONCLUSIONS.

Several other considerations now present themselves, but they are more or less outside the scope of this paper.

First. As to the location of such works as must necessarily and markedly affect the surrounding atmosphere. If it were possible, the

best location would be that of a flat and open plain, since quick dissemination and dilution of wastes are more certain there than in ravines or valleys where the surrounding slopes tend to retard and restrict their movement. Location, however, will probably always be dominated by other considerations, and at best, relief from air pollution through it is but a poor sort of a crutch.

Second. Tall stacks or chimneys should always be used, inasmuch as this is the most effectual aid to rapid and complete dilution. But too much dependence should not be placed upon them. Experience has shown many cases where they have proved totally inadequate to dispose of the wastes without direct and conspicuous injury to the neighborhood.

Third. Smoke consuming devices and means for reclaiming wastes should always be employed and their use be required and enforced by law. There is no more reason why the pollution of the atmosphere should be permitted than the pollution of water or earth. The economics of manufacturing may suggest the need of a more careful and complete combustion of coal or the reclaiming of wastes, but if they do not, then, for the good and well being of the community at large, the manufacturer should be required to put them in operation.

Smoke which darkens the air and blackens and defiles whatever it touches, and gases conspicuous to the sense of smell, are in several ways a menace to the health and well being, the comfort and convenience of the whole surrounding neighborhood. To a degree, attempt is made to regulate these matters by statute, but the provisions are local, rather than general, and have not kept pace with the rapid strides made by the manufacturing industries. So far as they have been employed, it has been with reference to city life and surroundings and has had no bearing upon the agricultural interests.

There should be a general law upon the subject defining what amounts of smoke and other wastes may be permitted in the air, and prescribing penalties whenever it is found that those amounts are exceeded. In the production of coke from which comes the greatest injury on the whole it would seem as though the interests of the producer would of itself suffice to introduce the more economical modern methods, or at least that they ought not to be much longer delayed. When it is considered that not only is one-third of the coal wasted in the ordinary method, but that this waste is chiefly diffused in the air to the obvious inconvenience and detriment of other industries, how significant becomes the following summary of the German methods:

"Nothing is more striking than the quiet and cleanliness which prevail about these establishments. Nothing is wasted; scarcely a

fleck of smoke escapes from the ovens, or rises from the tall chimneys. The air is clear and undefiled without, and luxuriant crops of grain and vegetables grow up to the very walls of furnaces and coking plants in this country, where every morsel of food is needed and where waste is considered a crime."—Coke and Its Manufacture, p. 297.—Fulton.

THE AGRICULTURAL USE OF LIME IN PENNSYLVANIA.

BY DR. WILLIAM FREAR, *Chemist of Experiment Station, State College, Pennsylvania.*

HISTORY.

The use of lime, or "burnt lime," as it is sometimes called, as a means of increasing the productiveness of soils dates back for many centuries. Existing evidences indicate that other calcareous substances, such as marl and wood-ashes, were used as fertilizers in a number of localities long before lime itself was employed for a similar purpose. The most ancient writers of Europe dealing with agricultural processes, refer to their use. Pliny (died A. D. 79) speaks of the application by the Greeks of marl to certain heavy soils as though the custom were one long known, and the Roman general, Varro (died B. C. 28), describes the applications of marl practised by the peoples dwelling in Britain and Gaul.

A. Dickson,* who has made a careful study of the Greek and Latin writers, asserts that lime was not used for agricultural purposes until about the time of Pliny, although its property as a mortar-making substance was well known long before. Cato (died B. C. 150), who wrote of the agriculture of his times, is, however, quoted by Loudon,† as follows: "If you cannot sell wood and twigs, and have no stone that will burn into lime, make charcoal of the wood, and burn in the corn (grain) fields the twigs and small branches that remain." Cato also gives a careful description of the construction of a lime kiln, which was apparently of the type known to-day as a "flame kiln." Loudon infers from the passage quoted that the lime was to be applied to the land, but it is not a necessary conclusion; the use of the waste twigs and faggots to yield wood-ashes for application to the land, in case they cannot be sold or better used for burning lime, is the only distinct recommendation contained in the sentence.

The application of lime was, in Pliny's time, confined by the Roman farmer chiefly to his vineyards and olive orchards; it was also quite a good deal used to hasten the maturity of fruiting of the cherry; but as to its use for ordinary farm crops, while it was occasionally practised, there is no indication that the practise was at all general.

*Husbandry of the Ancients, 1897, I, 280.

†Encyclopaedia of Agriculture, 6th ed., 1860, p. 25.

The Chinese, whose civilization stretches away beyond historical records, and whose agriculture is, in many ways, very advanced, esteem wood-ashes as the very best of manures. While they are aware, says Loudon,* of the fertilizing value of lime, they use it chiefly for the purpose of destroying insects.

During the Dark Ages following the decay of Roman civilization, social and political confusion almost entirely suppressed intensive and skilled agriculture, except as its best traditions were here and there preserved by the studious inmates of an occasional monastery; of this period, there is little agricultural record. It is clear, however, that the practice of liming had meanwhile been more or less continuously kept up. Sir Anthony Fitzherbert, the first prominent English writer on agriculture, in "The Book of Husbandry" (London, 1523), strongly urges the use of both lime and marl; and Gervase Markham, in "The Countrey Farme" (London, 1616), which is chiefly a compilation from the French, Italian and Spanish writers of the sixteenth century, mentions lime as an important addition to many garden soils and, for general cultures, to cold soils in particular.

Since those days, the application of lime has been continued in all those European countries where agriculture exhibits the highest degree of advancement, though with great differences in the manner of use, to which reference will later be made in the discussion of the various more important practical questions concerning liming. More particularly has the practice obtained in Scotland, Wales and the northern and western counties of England—that is, in the more humid regions.

In a private letter, Prof. R. Warington, of the University of Cambridge, long chemist to the Rothamsted Experiment Station, says: "Before the introduction of artificial manures, lime was, next to dung, the commonest manure employed by farmers in England. The use of lime has, in recent years, much diminished. A return to the former practice would be, in some cases, decidedly beneficial. * * In this neighborhood (Rothamsted) in which the subsoil of the fields is chalk, it was a common practice to sink pits into the subsoil and to spread over the fields the chalk brought up from below. * * The analysis of the Rothamsted soil shows that the first nine inches contains about five times as much lime as the second or third nine inches, a relation most unusual in the case of natural soils, and arising apparently from the ancient application of chalk to the land."

In Belgium, in those regions in Germany where the heavier soils prevail, and in France upon the lighter granitic soils, it is also much used.

Dehérain† states the revival of the use of lime in France did not

*Encyclopaedia of Agriculture, 161.

†Traité de Chimie Agricole, 516-7.

in all probability, occur until the beginning of the seventeenth century, and quotes from Oliver de Serres, *Theatre d'Agriculture* (I, 127), to the effect that its use had been followed for a long time in the districts of Gueldres and of Juilliers. At the present time, Dehérain states, the use of lime and of marl has wrought a veritable agricultural transformation in Mayenne, Sarthe, Limousin and So-logne.

It was naturally among the first materials which the European settlers in the New World used when bringing into tillage soils requiring especial treatment, such as swampy lands and very heavy clays. John Spurrier, in "The Practical Farmer" (Wilmington, Del., 1793, a subscription book numbering among its subscribers "George Washington, Esq., President of the United States"), one of the earliest American works on agriculture, treats quite fully of the value of lime in the amendment of such soils and shows a practical acquaintance with the results of its use, though, like other writers of the period, he offers very quaint theories to account for its action. Prior to the introduction of the modern commercial fertilizers, the common calcareous manures were very largely employed. In Canada and in New York and Pennsylvania, gypsum, or land plaster, was a very common application; where marls were readily accessible, especially in Canada and New Jersey, they were widely used and, despite their bulkiness and the great cost of their transportation, they were often carried many miles by rail for application to general farm lands. Wood ashes have been employed everywhere, Canada ashes still finding a large sale in the New England States, New York and northern Pennsylvania. Leached wood ashes, composed chiefly of carbonate of lime, are much used in New England. The use of burnt lime was especially prevalent in eastern Pennsylvania and New York; in certain localities, however, such as eastern Massachusetts, it is scarcely used at all; its difficult accessibility is not the reason for its disuse in many of these localities.

The introduction of commercial fertilizers, particularly the acidulated lime phosphates, potash salts and soluble nitrogenous fertilizers, greatly affected the use of lime in New York and Pennsylvania. While there are many farmers firmly fixed in the traditions of their fathers, who have clung to the use of stable manure and liming to the total exclusion of the artificial fertilizers, they were more numerous who dropped lime almost entirely out of consideration as a means of soil improvement, and the traveler will see in all those regions where lime was formerly used by all farmers, dismantled lime-kilns on every hand.

This tendency to exclude liming has, however, been strongly combatted; the question of "lime *versus* phosphates" has been mooted in some way or other at nearly every farmers' institute held in the

State, with the expression of highly divergent experiences with the contrasted materials and still more highly divergent theories of their several actions. The writer has been led to believe that, without at all diminishing the importance of the place assigned to the commercial fertilizer in farm practice, the use of lime is coming into renewed favor, and is gradually becoming more general. Many inquiries made of the writer, and many statements made by Pennsylvania farmers indicate, however, that the subject is one upon which much confusion of opinion still exists. Nor is this peculiar to Pennsylvania..

Storer* says: "As matters actually stand, the student is met at the threshold of the inquiry by so many different statements, so many possibilities and probabilities, that the subject is made to seem less clear than it really is. As has been said, the contrast between the current methods and practices of farmers in respect to the use of lime, are very remarkable. Why is it, for example, that so little lime is used in eastern Massachusetts, and why is it that such enormous quantities of it are used in other districts such, for example, as some parts of Pennsylvania, of France and of Germany? Indifference towards lime, or objection to it, is by no means peculiar to this particular locality. It is notorious that in some parts of the world landlords have often absolutely forbidden their tenants by contract from using lime, and the employment of it in agriculture at the present day cannot in any sense be regarded as a general practice."

LIMING IN NEIGHBORING STATES.

Before entering upon the consideration of Pennsylvania practice, a brief view of that of neighboring states will be of interest.

In Rhode Island, as a consequence of careful investigations made at the Rhode Island Experiment Station, the use of lime upon sandy upland soils has grown very rapidly, although it is only of recent date.

Hon. Geo. T. Powell, of Ghent, N. Y., well known to Pennsylvania farmers as an institute lecturer, writes: "There is no lime used in eastern New York." Dr. L. L. VanSlyke, of the New York State Experiment Station, virtually endorses this statement.

Of the practice in New Jersey, Prof. E. B. Voorhees, Director of the New Jersey Experiment Station, writes, that about one-third of the farmers in the northern and central sections follow it, but the use is decreasing. The quantity used is about the same as formerly, viz: 25 bushels of stone lime per acre, applied once in each period of four or, more commonly, five years. It is most frequently applied to wheat at the time of seeding, being spread after plowing and harrowed in. The lime is sometimes home-burned, but is generally pur-

*Agriculture, 4th ed., Vol. II, p. 120.

chased from dealers at a cost of 9 to 13 cents per bushel, and is hauled by the farmer for a distance of two to six miles. It is not allowed to stand in small heaps before spreading. Its best results are seen upon upland clays and shales.

As to Maryland, Director H. J. Patterson, of the Maryland Experiment Station, says that the use is confined to certain limited sections of the state, and appears, in some localities, to be on the increase. The lime is applied once in eight or ten years to land that it seeded down to grass; the amount applied is commonly fifty to seventy-five bushels, but only twenty to twenty-five bushels in some localities, and there is a general tendency toward the lighter applications. The application is commonly made after plowing, and the lime harrowed in; in some sections, top-dressings on wheat and grass are considerably practiced. The lime is not often allowed to stand in small heaps before application. Both oyster-shell and stone lime are used. Some farmers burn their own lime, but it is, for the most part, purchased of dealers in Pennsylvania, and in Washington, Frederick and Baltimore counties, in northern and northwestern Maryland. The cost at the kiln or warehouse is 8 to 12 cents per bushel, and the distance the lime is hauled is about six miles on the average, a haul of twelve to twenty miles being not infrequent. The effect of the application is especially noticeable in the improved growth of grass and clover, these plants often failing entirely when lime is not used.

Of West Virginia, Prof. L. C. Corbett, of the West Virginia Station, writes that in those sections where lime is easily produced by home-burning, about 10 per cent of the farmers follow the practice, but scarcely 1 per cent. in other sections. The lime is usually home-burned, but the limestone is occasionally hauled two to five miles. The quantity applied is not closely estimated, the abundance increasing as the cost of the lime is less, and one application serves for many years. The application is made directly from the wagon upon plowed ground, and the lime harrowed in. The river bottom soils are never limed, only the heavy clay uplands receiving the application.

In Ohio, says Director Thorne, of the Ohio Agricultural Experiment Station, the use of lime as a means of soil amendment, is very rare.

Leaving the humid regions and turning to the states possessed of a more or less arid climate, Prof. E. W. Hilgard, Director of the California Experiment Station, says of California: "Liming and marling are scarcely at all practised in this state, owing to the fact that nearly all the soils at present cultivated contain an excess of calcic carbonate, manifested either by effervescence with acid or the blueing of litmus paper after twenty minutes. The average lime content of California soils, as determined by extraction with hydro-

chloric acid, is over 1 per cent., and the character of the vegetation is almost throughout 'calciphile' (lime-loving). In a few cases where very heavy clay soils have been found poor in lime, I have recommended the use of quick-lime or marl, and it has been done with very good effect; as, also, at a few points in the 'tule' lands—coast marshes—bearing sour grasses. But even in these acidity is rather the exception than the rule, on account of the large proportion of lime contained in the river alluvium."

Speaking of the United States at large, Prof. I. P. Roberts* estimates that at least 99 per cent. of the arable land has never been limed, and it not likely to be in the near future—partly because lime is inaccessible, partly because the soil of certain great areas do not require it.

PRESENT PENNSYLVANIA PRACTICE.

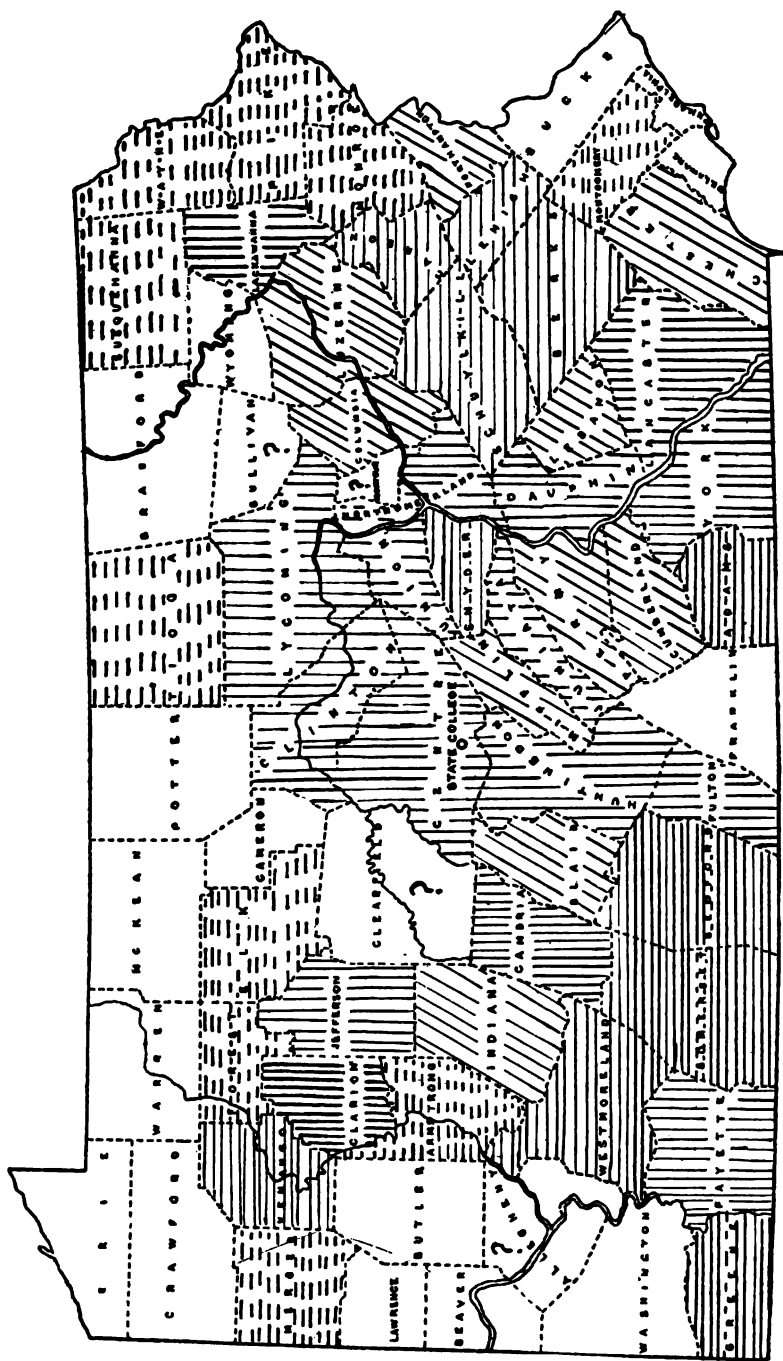
As an introduction to a discussion of the principles involved in the practice of liming, it has been thought that a careful survey of the extent and manner of its use in the several portions of the State would be valuable.

Accordingly, two series of questions were framed to cover the more important points of practice, and submitted respectively to a number of well-informed farmers in each county of the State, and to those lime dealers and burners whose addresses could be secured. The writer is indebted to a large proportion of the gentlemen to whom these queries were addressed, for their full and careful replies. From these replies, the statements of the practice that are given below in the various portions of the State have been compiled. The names of the several correspondents who have given this valuable assistance are given in Appendix A.

VARYING EXTENT OF PRACTICE.

The proportion of farmers in the several counties who use lime has been reported by the correspondents. The answers from the same county are often quite divergent, owing, doubtless, to the fact that because of differences in local conditions, one section of a county uses lime more than another. Necessarily, the number of correspondents from each county was too small to give a perfectly true representation of the extent to which lime is used. The percentage of farmers in each county who use lime upon their soils, whether with frequency or not, as gathered from the correspondence, is shown

*The Fertility of the Land, 1897, p. 305.



Over 75%

50 to 75%

25 to 50%

A few

None

? No report.

upon the accompanying map. When a percentage of less than five was reported, the use was considered as probably experimental and no representation made for it.

Of the sixty-three counties reporting, sixteen show no use of lime; in ten or more, it is used by only a few farmers, and in ten or more, by less than half, while in ten, it is said to be used to some extent by 75 to 100 per cent. of the farmers. The greater use is found in the eastern and southern parts of the State; with a few marked exceptions, the least on the extreme northern and western borders. As will be seen in a later presentation of the cost of lime in the several localities, one reason for its lack of application there is the high cost.

From this showing, it is very probable that the use of lime is far more prevalent in Pennsylvania than in any other American locality. The above statement gives no just notion of the soil area to which lime is applied. The surface of Pennsylvania is greatly broken into mountain, ravine and broad river valley. The rocks from which its soils are formed represent most of the well-known geological formations of North America. There is, in consequence, an almost bewildering variety of soil. The use of lime in each locality is largely restricted to specific kinds of land and no data are readily accessible to permit an estimation of the total farm area of Pennsylvania upon which liming is practised.

SOILS UPON WHICH LIME IS USED.

The inquiry as to the nature of the lands in each locality giving the best results from the application of lime, resulted in a number of general statements to which all agreed:

All soils, when rich in humus, whether new land or old soils long down in grass or heavily manured, respond well to liming, the lighter soils more promptly. It is used in large quantity on the "gladey" lands of Greene county and on certain low-lying black mucks in Snyder county.

With few exceptions, most excellent results are obtained on heavy clay soils, though the benefit often fails to appear if they are low-lying, wet and ill-drained; upland clays seem to give the best results. The white and bluish-white clays of Armstrong and Greene counties may be especially mentioned in this connection. In Pike county only is the result on light soil—gravels or sands—reported superior to that on clay.

"Limestone" land, which is usually clayey in nature, is commonly reported as benefitted by liming, but reports from Bedford county place the results on limestone soil with those on sand, and reports from Lehigh county say that these soils respond least to liming, particularly when the stone lies near the surface. Some limestones

leave a sand, instead of a clay; whether it is so in these cases has not been ascertained.

Sandy soils and bottom lands, except when richly supplied with humus, are usually reported to respond least to liming, but beneficial results are reported from Forest county from applications to soils that had lost their surface layers by flood. Report from Huntingdon county mentions a *heavy* sandy soil in a creek bottom, benefitted by liming, and in Lancaster county, with its broad belt of limestone clay land, the sandy soils are reported to respond best to the treatment.

Distinctly gravelly soils are commonly reported as responding well to liming, sometimes loam better than clay; but certain gravelly soils of Columbia, Indiana and Schuylkill show little benefit. Burning out of humus by heavy liming is noted from Cambria.

Certain soils received special mention in the several counties, and the facts concerning these are given below by counties:

Adams.—Ironstone soils especially benefitted; *blue* shales distinctly injured, *red* shales not.

Armstrong.—Excellent result on spouty clay, impregnated with ferrous sulfate, lying below coal outcrop.

Bedford.—Excellent results on upland slate and red shale soils.

Blair.—Much less effect on red shale than on limestone land.

Carbon.—Red shale ridge requires liming for clover.

Centre.—Light upland soils on spurs of Alleghenies respond liberally to its use for grass.

Clarion.—Light upland sandy soil—chestnut land, and clay, respond best.

Clinton.—Best results on red shale.

Cumberland.—Most beneficial on black slate.

Dauphin.—Flint, red shale and yellow slate soils respond well.

Elk.—Good on clay below coal outcrop, which yields an acid soil.

Franklin and Fulton.—Slate benefitted by judicious applications, often showing best result.

Huntingdon.—Slate lands do well, but can not bear heavy liming.

Indiana.—Slate land stands next to clay in benefit received.

Juniata.—Has little but quick results on shale, least on land underlaid with iron.

Lancaster.—Upland slate shows good results.

Lycoming.—Best results on red and gray shales.

Northampton.—Quite good on gravel and slate lands when new.

Schuylkill.—Best on red loam.

Somerset.—Best on red soils.

Tioga.—Better on red shale than on sand.

Union.—Slates respond least.

Venango.—Dry loam and sands respond well.

Washington.—On red shale there are no good results.

These statements tend to show that slate and shale lands commonly respond well to liming, though with some sharp exceptions, which are, probably, due to the difference in the extent to which the rocks forming the soils have broken down, some slates in particular breaking down very slowly and imperfectly.

In response to questions concerning the effect of liming upon the qualities of the soil, it is almost without exception answered that the heavy soils are made lighter, more porous and more easily tilled, and that they regulate the moisture supply more perfectly, so that crops growing upon them suffer less in extremely wet or extremely dry seasons than they did upon the same soil before liming. Of the lighter soils (gravels, shales and slates), it is said that they respond quickly to small applications and are made more compact and better able to retain moisture, but that with large applications they burn out or lose their humus to too great an extent.

TENDENCY TOWARD INCREASED USE OF LIME.

Irrespective of the methods of its use, the replies indicate that there is a very general tendency to return to a judicious use of liming for special purposes. Of eighty-four correspondents making reply upon this point, one-half state that its use is again on the increase in their respective localities, and only seven distinctly affirm that in their neighborhoods its use is decreasing.

Pennsylvania practice as to the methods of its use, shows wide divergences.

CROPS LIMED.

Considering first the nature of the crop to which it is applied: In most counties it is reported as being applied to ground preparing for corn, either before or after plowing; but in Blair, Bucks, Centre, Cameron, Crawford, Fayette, Forest, Pike, Susquehanna, Tioga, Venango, Washington, Wyoming and in certain sections of Cambria, Franklin, Huntingdon, Luzerne, Monroe, Northampton and Schuylkill it is either never so applied or with less frequency than upon grass or cereals. The prevailing custom is to plow the sod under, most often during the fall and winter, and apply the lime, after first harrowing and rolling, which operations are then repeated to secure the perfect admixture with the surface soil. In Adams, Armstrong, Bedford, Blair, Clinton, Dauphin, Lawrence, Northumberland, Tioga, Union and in some sections of Jefferson, Lebanon, Lehigh, Snyder and Somerset counties the lime is more commonly applied to the sod before plowing, during the summer if the plowing is to be done in the fall, or during the later fall and winter, if the plowing is deferred until springtime. Many of the correspondents remark that where lime is plowed under with the sod, especial care is taken to have the plowing shallow.

The occasional use of lime upon wheat is reported from nearly all localities, specific statements concerning it being absent only from reports of correspondents living in Berks, Clinton, Dauphin, Delaware, Lackawanna, Lawrence, Lehigh, Susquehanna, Washington and Wayne counties. Its use on rye is specially mentioned in reports from Blair, Fayette, Northampton and Pike counties, though its use on fall grains in general is reported in other localities. It is applied to oats, especially when sown with grass for seeding down, in Cambria, Fayette, Luzerne, Somerset, Susquehanna, Tioga and Wayne counties. When these cereals follow a sod, the application is made either before or after plowing, but when wheat or rye follows oats, the lime is not applied until the oats stubble has been plowed and harrowed.

Very commonly, the application to fall grains and to oats is for the benefit of the following crops of grass and clover. Later applications are not uncommonly made for the latter crops. In one instance, a light top-dressing on fall wheat some little time after seeding is mentioned; more frequently, the application is made after the removal of the grain. Reports from Blair, Bucks, Northampton and Snyder counties state that lime is frequently applied as a top-dressing to wheat stubble; in Centre, it is reported, clover is top-dressed by some; while its application in like manner to meadows and mowing lands is reported from Cameron, Clinton, Franklin, Indiana, Lackawanna, Lehigh, Mercer, Northampton and Washington counties.

Buckwheat land is limed before sowing in Lycoming and Monroe counties.

In Dauphin county, it is stated, lime is frequently used in preparing land for potatoes. It is applied as a top-dressing, with a heavy dressing of manure, upon the plowed ground and is then thoroughly worked into the surface by use of a spring-tooth harrow.

FREQUENCY OF LIMING.

The replies as to frequency of application can not be readily presented in compact form. In Bedford, Blair, Cumberland, Elk, Franklin, Fulton, Lebanon, Snyder and Westmoreland the applications are not usually made more frequently than once in ten, fifteen or even twenty years. In other districts using lime, it is stated that there is a very distinct tendency to make more frequent and lighter applications, light dressings every three to five years being cited in some localities, the lighter and more frequent dressings being made to light, open soils. The local cost of liming also influences the practice in this respect quite materially.

AMOUNT OF LIME APPLIED.

The quantities applied vary from 8 to 300 bushels of unslaked lime per acre, an enormous variation, though these extremes are rare,

the lowest extreme being mentioned as occasional in Crawford and in Warren counties, where lime is very costly and very infrequently used; the higher, in Greene and Fayette, where lime and coal are both abundant; even in these localities the application of such large quantities is rare. In most counties the quantities now used range from 50 to 100 bushels. The following tabulation shows where the exceptions to this rule most frequently occur:

Counties reporting the use of 25 bus. or less.	Counties reporting the use of no more than 50 bus.	Counties reporting the use of over 100 to 200 bus.	Counties reporting the use of over 200 bus.
Adams, Bedford, Chester, Crawford, Dauphin, Luzerne, Lycoming, Monroe, Montgomery, Tioga, Warren.	Adams, Bucks, Cambria, Carbon, Chester, Elk, Forest, Lackawanna, Lebanon, Luzerne, Lycoming, Perry (Eastern part), Susquehanna, Tioga.	Armstrong, Bedford, Cameron, Carbon, Fayette, Fulton, Huntingdon, Jefferson, Perry (Northern part), Snyder, Somerset.	Clarion, Fayette, Greene, Venango, Westmoreland.

MANNER OF APPLICATION.

It was formerly the common practice to draw the fresh lime, at any convenient season when the soil was in condition to be least injured by trampling, upon the field, and distribute it in small heaps of a few bushels measure; it was then allowed to stand, often for a long time, until the convenience of the farmer led him to spread it. The merits claimed for this system were that it allowed the greatest latitude of choice for times of hauling and spreading, reduced injury from trampling of the soil and resulted in complete slaking before spreading and dispensed with any necessity for reloading the lime, which is necessary when purchased lime is slaked in large heaps. Notwithstanding these claims, the practice has given way to the better, but less convenient method, of spreading as hauled or of slaking in large heaps, reloading and spreading. The practice still remains, however, in some widely distributed districts, being reported as the usual mode in Armstrong, Bucks, Carbon, Columbia, Cumberland, Dauphin, Elk, Forest, Franklin, Lackawanna, Lehigh, Lycoming, Mercer, Snyder and Union, and in some parts of Adams, Berks, Centre, Juniata, Mifflin, Somerset, Westmoreland and York. But even in these districts it is stated that great care is taken to spread the lime after the first rain or as soon as it is slaked, instead of allowing it to stand indefinitely, as was the too frequent practice in former years.

The spreading is commonly made on a quiet day, from wagon or heap, by means of a shovel. It is often said to be impossible to evenly distribute any amount less than eighty bushels by this method, but the great number of instances in which fifty bushels or less are

applied and the very infrequent use of special machinery for spreading, indicates that the inconvenience is easily overcome. The use of special lime spreaders is not mentioned by any correspondent and is quite uncommon. Those who have the modern manure spreaders find them excellent for an even distribution of lime. Correspondents from Crawford and Fulton counties state that lime is frequently applied in those localities by means of the grain drill; where the lime has been well screened, this method of applying small dressings strongly commends itself.

THE LIMESTONES OF PENNSYLVANIA.

There are only three materials that are largely used as sources of lime: Sea shells of various sorts, limestone and, in England, chalk, which is really a very loose-grained, slightly coherent limestone; a fourth material, rarely employed, is coral rock.

NATURE OF LIME.

The chief constituent of all these materials is calcium carbonate, more commonly spoken of as "carbonate of lime." This substance, when heated to a rather high temperature, gives off carbonic acid gas (carbon dioxid), and there remains lime (calcium oxid), often called "fresh burned," or "caustic" lime, to distinguish it more certainly. The lime remains for some time in lump form, in which form it is called "stone lime." If, however, water is poured or sprinkled upon it, or if it be immersed in water, it breaks down into a fine powder or into a paste or thin fluid, according to the proportion of water used; this process is called "slaking," and really consists in a chemical union of water and the calcium oxid, whereby much heat is liberated; the substances swell and sometimes become hot enough to bubble violently and liberate steam, and there is formed a new compound known as "slaked lime" (calcium hydrate). If stone lime be exposed to the air, it slowly takes up moisture therefrom and falls into powder, containing much calcium hydrate, though the operation proceeds so slowly that the heat liberated passes off gradually and never becomes intense. The calcium hydrate is quite soluble in water, and the lime water so often prescribed by the physician is nothing but a solution of calcium hydrate. Any one who has used lime water has noted that the clear liquid presently forms a white film upon its surface and a white deposit on the sides and bottom of the bottle

containing it; this film and deposit are composed of carbonate of lime, for the hydrate unites very readily with the carbonic acid present in the air, thus returning to the state of chemical combination in which it existed before being subjected to "burning." A similar change occurs in slaked lime exposed, in the form of powder or paste, to the action of the air, and in "air-slaked" lime—that is, in stone-lime slaked slowly by absorption of moisture from the air—there is always quite a large amount of carbonate of lime. Some of these changes will be considered more fully in later paragraphs.

The use of oyster-shell lime is confined to a few sea-coast localities. Inland districts must rely upon the extensive deposits of limestone found in many parts of our country. It will conduce to a better understanding of some questions frequently asked concerning the agricultural uses of lime, if the history and nature of limestone be somewhat carefully considered.

GEOLOGY OF LIMESTONE FORMATION.

When the globe was first cooled down, the lime combined chiefly, with other bases, in the form of silicates, such as feldspar, amphibole or pyroxene. It is one of the most abundant basic materials of the globe, aluminum and iron alone surpassing it. Prof. F. W. Clarke,* Chief Chemist of the U. S. Geological Survey, estimates that calcium (the metal of which lime is the oxygen compound, and which constitutes 71.4 per cent. of lime) makes up 3.77 per cent. of the crust of the earth, taken to a depth of ten miles, 74.5 per cent. of the crust being made of oxygen and silicon. The primitive crystalline rocks of which the crust is supposed to have been at first exclusively formed, contain from 1 to 15 per cent. of lime.

LIME LIBERATED FROM ROCKS.

These rocks, however, under the action of atmospheric agencies, and especially of carbonic acid and water, gradually weathered or decomposed; as a result of the weathering, the lime was changed from a silicate into the carbonate or acid carbonate, sulfate and nitrate, and these, in turn, were dissolved by the rain and carried off to the ocean. T. Mellard Read† estimates that at the present time the rainfall annually removes from the average square mile of the earth's surface the following quantities of the more common mineral constituents:

	Tons.
Calcium carbonate,	50
Calcium sulphate,	20
Silica,	7

*Bulletin, Philosophical Society of Washington, 2, 142; Wiley, Agricultural Analysis, I, 22.

†O. Merrill, Rocks, p. 194.

	Tons.
Magnesium carbonate,	4
Iron oxid,	1
Common salt,	8
Alkaline carbonates and sulphates,	6
	<hr/>
	96
	<hr/>

LIME IN SEA WATER.

The composition of the sea water shows quite a different proportion among its several constituents, as illustrated by an analysis by Thorpe and Morton* of the waters of the Irish Sea in the summer of 1870:

One thousand parts of the sea water contain—	Parts.
Sodium chlorid (common salt),	26.43312
Potassium chlorid,	0.74619
Magnesium chlorid,	3.15823
Magnesium bromid,	0.07622
Magnesium sulfate,	2.00026
Magnesium carbonate,	Traces.
Magnesium nitrate,	0.00307
Calcium sulfate,	1.23153
Calcium carbonate,	0.04754
Lithium chlorid,	Traces.
Ammonium chlorid,	0.00044
Ferrous carbonate,	0.00526
Silica,	Traces.
	<hr/>
	33.85946

Estimating the corresponding amounts of lime (calcium oxid) in the annual loss from the earth's surface as found by Reade and in sea water, we find that of the former 37.7 per cent. is lime; of the latter, only 1.7 per cent. In other words, the proportion of lime in sea water is very much less. One cause for this would be found in the removal of lime, in one form or another, from solution. Another fact of interest is that while in the material removed from the earth's crust the carbonate of lime is 2.5 times as abundant as the sulfate; in the sea water the latter is over twenty-eight times as abundant as the carbonate. It might be inferred therefrom that the carbonate had been removed far more rapidly than the sulfate.

The foregoing analysis of sea water shows it to contain one part of carbonate of lime in 20,000 parts of water. Comey, in his *Dictionary of Solubilities* (p. 82), quotes Irvine and Young as stating that one part of the carbonate is, according to its condition and fineness, dissolved by 1,600 to 8,000 parts of sea water, whose solvent action for this substance is greater than that of pure water. It is evident that the lime is not separated or precipitated from the solu-

*Chem. Soc. Journ., 24, 506; Roscoe and Schorlemmer, *Treatise*, I, 267.

tion in sea water by any method known to the laboratory, and Bischof* states that the ocean at present contains seven times as much carbonic acid as is necessary to retain all the lime in solution, and that for its deposition upon the sea bed living organisms must, therefore, intervene.

CALCIUM CARBONATE SECRETED BY ANIMALS.

As a matter of fact, it is found that the skeletons or shells of many of the lower animals living in the sea are quite largely made up of carbonate of lime; the coral polyps, foraminifera, brachiopods, crustaceans and many lamellibranchs and gasteropods may be cited as belonging to this class. Dana† cites some analyses by S. P. Sharpless that serve to show how largely carbonate of lime is taken up by these organisms.

	Madrepore coral. Per cent.	Oculina coral. Per cent.	Shell of <i>Terebratula</i> . Per cent.	Oyster shell. Per cent.
Calcium carbonate,	97.19	95.37	98.33	98.90
Calcium phosphate,	0.78	0.84	0.61	0.50
Calcium sulfate,				1.40
Magnesium carbonate,				0.30
Water and organic matter,	2.81	3.79	1.00	3.90
	100.78	100.00	100.00	100.00

The temperature of the deep sea is too low to allow these forms of life to flourish there. Murray, in reporting the results of the deep-sea explorations of the *Challenger Expedition*, states that the ooze from deep-sea bottoms is of a reddish color, is largely composed of iron oxid and contains little lime; if the rhizopods (foraminifera) and other minute organisms find a fitting home near the surface of the mid-ocean their skeletons are probably dissolved when, after the death of the animal, they slowly sink toward the sea bottom; to give further probability to this theory, analyses of carefully taken samples of water from the lower depths of the deep sea exhibit a larger proportion of lime than is found in the surface waters. The best known lime-secreting organisms of the present day do not live in water deeper than 100 fathoms, nor is the wave action at great depths sufficiently strong to pulverize the shells, coral, etc., whose debris deposited as ocean slime, later becomes the solid bed of limestone. As somewhat illustrating these differences there may be cited certain analyses by Storer‡ of two series of deposits from the sea bottom, (1) a series taken by Lieut. Berryman, U. S. N., off the coast of Nova Scotia, near the northern edges of the Gulf Stream, at depths

*Cited by Reid: Portland Cement, etc., 1877, p. 50.

†Manual of Geology, p. 211.

‡Bulletin of the Bussey Institution, Harvard University, II, 21-3.

of 1,100 to 1,300 fathoms; (2) a series taken by Lieut. Brooke, U. S. N., in the Pacific ocean, between California and China, in the track of the Equatorial and North Pacific currents, at depths of 900 to 3,000 fathoms, chiefly at the greater depths:

	(1)	(2)
Silica and sand,	49.5 to 51.1	60.4 to 74.8
Alumina and ferric oxid,	7.7 to 8.3	12.4 to 19.0
Lime,	17.1 to 18.8	1.4 to 3.7
Magnesia,	1.7 to 1.8	1.6 to 3.3
Phosphoric acid,	0.3 to 0.3	0.3 to 2.0
Potash,	2.1 to 5.3	2.1 to 4.1

If further evidence is necessary, it is furnished by an examination of the limestone rocks themselves. In many, the shell forms and coral structure are distinctly preserved; under the microscope, the oolitic limestone plainly reveals its animal origin, while the chalk cliffs of southern England are built up almost wholly of the skeletons of foraminifera, over a million of which are requisite to make one cubic inch of chalk.*

DECOMPOSITION OF CALCIUM SULFATE.

One other fact should be mentioned in accounting for the tremendous deposits of limestone that mark the later history of the earth's crust, namely, that the lime carried to the sea in the form of carbonate is not the only supply from which these great formations were built, but the sulfate also contributed in an important measure. While the loss from the earth's surface in percolating rain, estimated by Reade, and the analysis of sea water by Thorpe and Morton, do not warrant too close comparison, it is clear that, as compared with the common salt, the sea water contains much less sulfate of lime than the waters of percolation. While this compound, as it occurs in gypsum or land plaster, is considered to be one of the less readily destructible compounds known to man, it is well known to plant chemists, that the crops can take it up and that the plant stem, at later stages of growth, is sometimes free from sulfates, under such conditions that the destruction of these salts to furnish sulfur for the building of albuminoids is believed to be established. The decomposition of calcium sulfates to form the sulfid through the activity of lower plant life seems also to be well established, and Olivier and Etard† claim that certain algae may even set sulfur itself free from sulfate of lime. Bernard‡ has noted the liberation of sulfuretted

*Stockbridge, *Rocks and Soils*, 1896, pp. 25-8.

†Cited by Bernard: *Le Calcaire*, 1892, p. 245.

‡*Ibid.* cit.

hydrogen as a consequence of the reduction of sulfate of lime in springs and in sea water when abundance of organic matter was present. Buchanan* has shown that the mud of the sea bottom, which is being continually passed through the alimentary tracts of marine animals, has the sulfate of lime it contains reduced under this treatment, to calcium sulfid, the same from that results from the reducing action of water plants to which reference has just been made.

The formation of calcium sulfid being established, it remains to be noted that this substance when dissolved or suspended in water containing carbonic acid, is quickly decomposed with the liberation of sulfuretted hydrogen and the formation of carbonate of lime.† Dehérain‡ states that sulfids formed in soil rich in humus very quickly undergo similar conversion into the corresponding carbonates.

From these facts it is clear that the great limestone formations have drawn for their material not simply upon the lime brought to the sea in the form of carbonate, but also indirectly upon that brought down in the form of sulfate.

QUANTITIES OF LIME IN PENNSYLVANIA LIMESTONE ROCKS.

The writer estimates, assuming the limestone to have a specific gravity of 2.7 and that it contains roughly an average of 80 per cent. of carbonate of lime, that the Lower Silurian lime formations of Central Pennsylvania, which are about 5,000 feet, or nearly a mile, in thickness, contain upwards of 94,000,000 of tons of calcium carbonate for each square mile of these strata. While the mind can not conceive of such enormous quantities, they serve to impress upon the imagination the wonders of these great geologic changes.

LATER CHANGES IN LIMESTONE.

These beds, after being raised above the surface of the ocean by some of those frequent changes of level that have marked the history of the earth's crust, have not only become comparatively dry and solidified but, in consequence of pressure, heat and other changes have often assumed a crystalline character such as is exhibited in the pure limestones yielding fine marble. Percolation of surface waters through beds of limestone have dissolved§ much of the carbonate of lime in many localities and strata, leaving the more easily attacked rocks greatly honey-combed; indeed, the great caverns of

*Proc. Roy. Soc., Edinburgh, 1890-1, cited by Merrill, Rocks, p. 304.

†Malaguti, Leçons de chimie, II. p. 150.

‡Traité de chimie agricole, p. 547.

§Note.—The authorities cited by Comey (Dictionary of Solubilities, p. 83) indicate that one part of calcium carbonate requires, according to its condition of subdivision, hardness, etc., from 10,001 to 100,000 parts of water for its solution. If, however, the water be saturated with carbonic acid, as soil water often is in part, only 800 to 3,149 parts are required to dissolve one part of the carbonate, the acid calcium carbonate being thereby formed.

the limestone regions, such as the Mammoth Cave, of Kentucky, Luray Caverns of Virginia, and the interesting Penn's Cave, of Central Pennsylvania, have been formed by this dissolving, percolating process.

IMPURITIES IN LIMESTONES.

The history of the limestone formations renders it also apparent that great quantities of material other than calcium carbonate must have entered into their composition. The sedimentary limestones in which crystallization does not appear, are colored, not white, and often contain large quantities of *sand*, *clay*, whose deposition upon the shallow sea bottoms from the down-wash of neighboring uplands is readily understood, and of *iron pyrites* (sulfid of iron). When the limestone crystallized, the same conditions brought about changes in the accompanying impurities, and Merrill* mentions, as accessory to crystalline limestone and resulting from such changes or originally present, minerals of the mica, amphibole and pyroxene groups, and frequently sphene, tourmaline, garnets, vesuvianite, apatite, pyrite, graphite, etc.

Owing to their animal origin, the presence of small quantities of *carbonaceous matter* in limestone is not surprising. The dolomitic limestones of Cook county, Ill., contain so much material of a bituminous nature that, when struck by hammer, a distinct odor like that of petroleum is evolved.

For the same reason the presence of *phosphorus* is to be anticipated and, according to Merrill,† the quantity of phosphoric acid in limestone often exceeds that found in either the older siliceous rocks or in other rocks of more modern formation. He gives the following ranges for the percentage of phosphoric acid in some of these rocks:

	Per cent.
Granite,	0.07— 0.25
Diorite,	0.18— 1.06
Basalt,	0.03— 1.18
Limestone,	0.06—10.00
Shale,	0.02— 0.25
Sandstone,	0.00— 0.10

The higher percentage given for limestone is one that is very rarely obtained.

The *color* of limestone, marble and travertine (onyx marble) may be white, yellow, brown, red, green, gray, blue or even black. These colorations are sometimes due to carbonaceous matters, sometimes to metallic oxids, iron oxids especially, and sometimes to both. In the white and green varieties, according to investigations of Merrill,‡

*Rocks, p. 162.

†Rocks, pp. 7-8.

‡Cp. cit. p. 558.

the iron exists as carbonate, in the yellow, brown and red forms, as a more or less hydrated sesquioxid of iron. Bernard* attributes the blue colors of limestone chiefly to organic matters, having found from 1.25 to 2.38 per cent. of such matters in the blue oölitic limestone taken from the bed of the river Marne, in France. The same investigator found, in a clear yellow limestone, in addition to some suspended yellow sesquioxid of iron, to which its color was due, a large quantity of ferrous iron, doubtless present in the form of carbonate. The changes of color which some limestones experience when exposed to the weather are chiefly due to the destruction of the organic matter and to oxidation of the ferrous carbonate and sulfids they contain.

The flint present in many limestones is believed to be derived chiefly from members of the sponge family, which contain considerable silica.

MAGNESIAN LIMESTONES.

There remains for brief consideration the most striking and difficultly explicable foreign constituent of lime, magnesium carbonate, from which few limestones are entirely free, and which is often present in equal molecular proportion with calcium carbonate, forming the mineral *dolomite*; this contains 46.5 per cent. of magnesium carbonate. There are no marine organisms now in existence whose skeletons contain any such proportion of magnesium carbonate. Dana† cites Damour as having found 19 per cent. in corals of the gums *Millepora*, and Forchhammer as having found 6.36 per cent. in *Isis nobilis*, and 2.1 per cent. in the precious coral of the Mediterranean. A single case of magnesian fossil (*Orthoceras*) is mentioned by Dr. T. Sterry Hunt‡ as containing 37.8 per cent.; it was found in the non-magnesian Trenton limestone at Bytown, Canada. Neither is the theory satisfactory that the calcium carbonate was dissolved out by water, leaving behind the magnesium carbonate, whose proportion was thereby increased; no known sea-bed formation of this day contains more than 4 or 5 per cent. of magnesium carbonate; in other forms than dolomite, the magnesium carbonate is more soluble than that of calcium;§ and so large a withdrawal of material from the bed must, it is believed, result in dolomite being universally crumbled or porous; whereas, on the contrary, it is usually more compact than ordinary limestone, and contains fossils of unchanged form.

The more commonly accepted theory for the formation of limestones rich in magnesia is that the sea water has given up magnesia

*Le Calcaire, pp. 193-4.

†Manual of Geology, p. 211.

‡Ibid., p. 69.

§Note.—Corney (Dict. Solubilities, p. 87) cites authorities to show that one part of magnesium carbonate requires for solution 5,071 to 17,600 parts of pure water, and from 23 to 3,700 parts of carbonated water. The action of sea water is not stated.

in exchange for lime from the rock. The known facts do not make the theory entirely satisfactory, but it is less objectionable than the others proposed.

Dolomites weather, as a rule, more slowly than pure limestones, though there are exceptions to the rule; they do not give off carbonic acid with effervescence when touched with cold hydrochloric or acetic acid as pure limestones do, and their density is greater, the specific gravity of dolomites ranging from 2.8 to 2.95, while that of pure, compact limestone ranges from 2.6 to 2.8, though both are heavier than the average other rocks from which both are formed.

LIMESTONE FORMATIONS OF PENNSYLVANIA.

It has been remarked in an earlier paragraph that this state has a great variety of rock materials. J. D. Dana (Manual of Geology, 3d ed., 1879, p. 375), describes the sequence of exposed geological formations in Pennsylvania as follows, beginning with the lowermost or oldest that has been certainly identified:

PALAEOZOIC TIME.

SILURIAN AGE, OR AGE OF INVERTEBRATES:

Lower Silurian:

PRIMORDIAL PERIOD, *Potsdam Epoch*: Sandstone and slates, 3,000 to 4,000 ft. thick.

CANADIAN PERIOD, *Calcifera Epoch*: Calcareous sandstone, 250 ft.

Quebec and Chazy Epochs: Magnesian limestone, with some cherty beds, 5,400 ft.

TRENTON PERIOD, *Trenton Epoch*: Limestone, with blue shale, 550 ft.

Utica Epoch: Bituminous shale, 400 ft.

Cincinnati Epoch: Blue shale and slates, with some thin gray calcareous sandstones, 1,200 ft.

Upper Silurian:

NIAGARA PERIOD, *Oneida Epoch*: Gray sandstone and conglomerate, 700 ft.

Medina Epoch: Red sandstone and shale, 1,050 ft., and white sandstone, with olive and green shales, 760 ft.; total, 1,810 ft.

Clinton Epoch: Shales of various colors, both argillaceous and calcareous, with some limestones, ferruginous sandstones and iron-ore beds, 2,600 ft.

Niagara Epoch: Not well defined.

SALINA PERIOD, *Saliferous Epoch*: Variegated marls and shales, some layers of argillaceous limestone, 1,650 ft.

LOWER HELDERBERG PERIOD: Limestone, thin-bedded, with much chert, 350 ft.; encrinal and coralline limestone, 250 ft.; total, 600 ft.

ORISKANY PERIOD, *Oriskany Epoch:* Calcareous shales and calcareous and argillaceous sandstone, 520 ft.

DEVONIAN AGE, OR AGE OF FISHES:

CORNIFEROUS PERIOD, *Cauda-galli Epoch:* Silico-calcareous shales, 200 to 300 ft.

Corniferous Epoch: Massive blue limestone, 80 ft.

HAMILTON PERIOD, *Marcellus Epoch:* Black and ash-colored slate, with some argillaceous limestones, 800 ft.

Hamilton Epoch: Argillaceous and calcareous shales and sandstone, 1,100 ft.

Genesee Epoch: Black calcareous slate, 700 ft.

CHEMUNG PERIOD, *Portage Epoch:* Dark gray, flaggy sandstones, with some blue shale, 1,700 ft.

Chemung Epoch: Gray, red and olive shales, with gray and red sandstones, 3,200 ft.

CATSKILL PERIOD: Red sandstone and shale, with some conglomerate, 6,000 ft.

CARBONIFEROUS AGE, OR AGE OF COAL:

SUB-CARBONIFEROUS PERIOD, *Lower Epoch:* Coarse, gray sandstones and siliceous conglomerate at the east, becoming fine sandstones and shales at the west, 2,660 ft.

Upper Epoch: Fine red sandstones and shales, with some limestone, 3,000 ft.

CARBONIFEROUS PERIOD, *Millstone-Grit Epoch:* Siliceous conglomerate, coarse sandstone and shale, including coal beds, 1,100 ft.

Coal measures, 2,000 to 3,000 ft.

The more recent explorations of the Second Geological Survey of the State add to the formations given in this list. In the first place, of the rocks of the Azoic Age, or that before the appearance of life on the globe, there is an exposed thickness of 15,000 feet cut by the Schuylkill River, made up of crystalline silicates.

At the other extreme of the geological scale, in the Mesozoic, or Reptilian Age, the Triassic and Cretaceous Periods are distinctly represented, the former by red granitic sandstone, with conglomerate, occasionally impure limestone and rarely shale, and with numerous ridges and dikes of trap rock; in Bucks county the maximum thickness of 27,500 feet is reached. The Cretaceous Period is represented by a brick-clay and gravel formation, occupying a very small area on the Delaware river, just below Trenton; it is a continuation of the formation so distinctly marked in New Jersey by beds of green-sand marl.

In many localities the thicker limestone strata are, of course, buried far below the surface; but even in such case, the deep channel of a river bed or valley often renders them accessible.

The geological map of the State shows that the Lower Silurian limestones form the surface of the land in three, more or less broken belts stretching from the eastern border, in a southwesterly direction, across the southeastern portion of the State. The first belt appears in Bucks, Montgomery, Chester, Lancaster, York and Adams counties; the second in Northampton, Lehigh, Berks, Lebanon, Dauphin, Cumberland and Franklin, while the third, much broken, appears in the numerous parallel curved valleys crossing the southern central portion of the State, in Fulton, Bedford, Perry, Mifflin, Juniata, Blair, Centre, Union, Clinton and Lycoming counties.

The Lower Helderberg limestone formation appears exposed on the mountain sides in very narrow and thin belts, in every county south of Pike, Luzerne, Sullivan and Tioga that lies between the main range of the Allegheny mountains, on the west, and, on the east, the depression crossing the State from Easton to Chambersburg.

In many parts of western Pennsylvania limestones of the coal measures are available.

Replies from correspondents show that in the northern counties lime is little used, because of its having to be brought in from other localities at great cost, as in case of the small quantities reported in use in Pike, Wayne, Tioga, Cameron, Elk, Forest and Crawford counties; in the western counties south of these, except in Clearfield, for which no report was received, and Beaver, where none is used, many of the farmers are reported as burning their own lime.

Neither time nor space will permit in this paper a discussion of the various strata and localities from which limestone may be obtained in each county of the State. One interested in that question should refer to the reports issued for the county by the Second Geological Survey of Pennsylvania.

As will be made more fully evident in the later discussion of the composition of limes, some knowledge of the composition of a limestone which it is proposed to use should be had before going to any considerable expense in quarrying and burning it.

As a matter of more interest geologically than from a practical point of view, it may be stated that researches by the Kentucky Geological Survey indicate the older limestones to be, as a general rule, richer in soda, phosphoric acid and, when non-magnesian, in carbonate of lime, than are the younger or more recently formed, and correspondingly poorer in silica and insoluble silicates (clay, etc.).

ANALYSES OF PENNSYLVANIA LIMESTONES.

It has been thought that some value might be derived from a compilation of available analyses of limestones from various localities in the State. Such a compilation, chiefly from the reports of the Second Geological Survey, has been made under the writer's direction by Mr. C. A. Browne, Jr., Assistant Chemist of the Pennsylvania State College Agricultural Experiment Station. These are presented in Appendix B.

VARIABILITY OF LIMESTONE FROM SAME QUARRY.

It is not probable that the analysis of any single specimen of limestone will correctly represent the entire output from a quarry. The stone varies in composition through the same stratum or bed; but especially are differences of composition observed in the stone from different strata in the same quarry. The most complete study of such variations known to the author is that made by Prof. Peter J. Lesley and Dr. Andrew S. McCreath* upon the composition of the stone of 115 beds exposed in the Walton (McCormick) quarry, opposite Harrisburg. As a typical example of the results obtained, the analyses of rock from the last five beds (Nos. 111-115) may be taken, two samples, one from each end of the sloping bed, having been analyzed in each stratum:

Bed No.	Thickness of bed. Ft. In.	Calcium carbonate.		Magnesium carbonate.		Insoluble matter.	
		Lower sample.	Upper sample.	Lower sample.	Upper sample.	Lower sample.	Upper sample.
111,	5-8	94.5	88.4	2.7	8.3	1.9	2.6
112,	1-7	84.4	84.4	25.2	26.2	8.4	7.7
113,	5-8	98.1	79.2	0.9	3.7	1.0	18.2
114,	5-8	84.6	85.4	26.2	23.8	8.5	9.7
115,	14-8	95.1	97.7	1.9	0.9	1.7	1.4

Among the beds retaining their individuality of composition throughout their entire exposure, were some of not more than eight inches thickness.

RANGE OF COMPOSITION.

An examination of the compiled analyses shows that the several important constituents range in proportion from a faint trace to the following maximum percentage:

	Per cent.
Insoluble,	80.95
Iron and aluminum oxids,	10.07

*Report of the Second Geological Survey of Pennsylvania, Vol. MM, pp. 311-361, and Final Report, Vol. I, pp. 327-336.

	Per cent.
Calcium carbonate,	99.30
Magnesium carbonate,	46.00
Sulfuric acid,	6.08
Phosphoric acid,	1.82

There were very few true dolomites among these samples. Some of them contained so much impurities that they can not properly be called limestones, but should be termed calcareous shales, sandstones, etc. The quantity of phosphoric acid will scarcely average as high as 0.1 per cent.

LIMES AND LIME BURNING.

Limestone and other forms of calcium carbonate, it has been remarked in an earlier paragraph, lose carbonic acid when heated and are thereby converted into calcium oxid, or lime. Upon complete burning, 100 pounds of pure calcium carbonate yield 56 pounds of lime.

TEMPERATURE OF LIME-BURNING.

To effect this decomposition a high temperature is required. Thorpe and Grove, in their treatise on "Manufacturing Chemistry," state that the disengagement of carbonic acid first begins at a temperature of 752 degrees Fahr. (400 degrees C.), a temperature somewhat above the highest employed in a baker's oven, but that this disengagement does not go on fully until a temperature of 1,494 degrees Fahr. (812 degrees C.) is reached.

The conclusions of other observers differ somewhat from those of Thorpe and Grove. Thus, Hans A. Frasc^{*} states that the normal temperature of burning is 850 degrees C. (1,562 degrees Fahr.); that pure calcium carbonate heated for four hours at 615 degrees to 675 degrees C. (1,139 degrees to 1,247 degrees Fahr.), lost none of its carbonic acid; for three hours at 860 degrees to 880 degrees C. (1,580 degrees to 1,616 degrees Fahr.), lost less than 10 per cent., but heated for two hours at 850 degrees C. it lost all its carbonic acid. Heated very intensely the pure carbonate fuses and the escape of the carbonic acid is almost entirely prevented.

As to the effect of heating upon the other constituents of the limestone, whatever the intermediate reactions may be, the final outcome

^{*}The Mineral Industry, Vol. VII (1899), p. 498 seq.

is that the carbonates of magnesia and iron give off their carbonic acid, and remain as magnesia and ferric oxid; iron pyrites loses its sulfur and is likewise oxidized; all organic matter is driven off or destroyed, and water, which is present as "quarry water" to the extent of 0.3 to 5 per cent., and often also in some small quantity as water of combination with sulfate of lime, and hydrated iron and aluminum oxids is expelled. Sand and other insoluble impurities are assumed, if the stone be carefully heated, to undergo little or no change. Calcium sulfate and calcium phosphate, if the phosphoric acid present is really combined with calcium rather than iron or aluminum, are supposed to undergo no change in their final state of combination, though no careful investigation of this point is known to the writer.

LOSSES DURING BURNING.

In the following table a simple example of the loss which the several constituents of a limestone undergo in a perfect burning is given:

Constituents.	In 100 lbs. of the original stone. Lbs.	Loss. Lbs.	Residual lime. Lbs.	Percentage composition of the fresh-burned lime.
Water (both quarry water and water of combination) and organic matter,	3.00	3.00	.....	.....
Sand, clay, phosphate of lime, and anhydrous sulfate of lime, and oxids of iron and aluminum,	7.00	.....	7.00	†12.75
Calcium carbonate,	70.00	30.80	39.20	70.07
Magnesium carbonate,	19.00	9.96	9.04	16.18
Ferrous carbonate,	1.00	.38	.62	.....
	100.00	44.13	55.87	100.00

*In its conversion to ferric oxid, 1 part of ferrous carbonate takes up .07 parts of oxygen from the air.

†Including the ferric oxid from ferrous carbonate.

That is, there remains none of the water or organic matter, all the sand, clay, etc., besides ferric oxid equivalent to 69 per cent. of the weight of the ferrous carbonate in the limestone, magnesia equivalent to 47.63 per cent. of the magnesium carbonate and lime equivalent to 56 per cent. of the calcium carbonate. These factors may be applied in estimating the yield of lime from limestone whose composition is known.

YIELD OF LIME.

Several questions concerning the yield of lime are frequently asked. 1. How much stone is required to yield a bushel of fresh-burned lime? Taking a stone of the composition first given, and the standard weight of 72 lbs. for the weight of the lime, the answer would be $\frac{100}{56}$ of the

lime (72 lbs.), or 128.6 lbs. With poorer limes, the weight required is less. 2. How much lime will a perch of limestone yield, assuming proper burning? This, evidently, depends upon two things; first, the density of the stone and its freedom from pores, which determine its weight; second, its composition, by which the loss during burning is determined. For illustration, take the two very simple cases of marble and of dolomite, which are each supposed to contain, as the only material other than carbonate, 2 per cent. of water and organic matter. Fair average specific gravities for these substances are, for marble, 2.72; for dolomite, 2.9; so that the weight of a cubic foot of water being 62.5 pounds, the weight of a cubic foot of these rocks would be 170 and 180.25 pounds, respectively; and a perch of the solid material ($24\frac{1}{4}$ cu. ft.) would weigh, for the marble, 4,207.5 lbs.; for the dolomite, 4,234.67 lbs. The residue from burning 100 lbs. of the marble would be 56 per cent. of 98 lbs. (the amount of carbonate of lime present), or 54.9 lbs., so that one perch would yield 2,309.9 lbs., or $32\frac{1}{4}$ standard bushels of 72 lbs. each. Each 100 lbs. of the dolomite would yield 51.8 per cent. of 98 lbs., or 50.8 lbs. of lime, (lime and magnesia, more correctly), equivalent to a yield of 2,151 lbs., or 29.9 standard bushels, for each perch of the solid stone.

METHODS OF BURNING.

Lime is burned in Pennsylvania both in "heaps," similar to those for preparing wood-charcoal, and in kilns of various types. Either wood or coal, or in some cases, both, are used as the fuel. The coal used is usually bituminous, of which the "slack," or cheaper grades are often employed.

BURNING IN HEAPS.

Burning in the "heap" is practiced in Centre county about as follows: A convenient oblong piece of ground is cleared, and leveled if need be, to secure a fit platform. Upon this is laid a layer or two of good cord-wood, better well seasoned. Between the chinks in the cord-wood, shavings, straw or other light kindling is placed. The stone having been reduced to the size of a double fist, sometimes not so small, is laid upon the cord-wood, care being taken to leave chinks between the stones just as between the bricks in a brick kiln; it is preferred that this layer of stone should not exceed six to ten inches. In some cases, temporary wooden flues, filled with straw, are erected, either one at the center or, if the heap is oblong, one near each end, and the stone and coal are built up around them; thus, when they are burned out, a chimney draught or two is secured, which may be damped by pieces of stone or sod. Upon this layer of stone is spread a layer of coal, and upon that a thicker layer of stone (12 inches), and so on, coal and stone alternating until the

oblong heap is topped with smaller stone. The proportion of coal is diminished in the upper layers, the effort being to distribute one-half of the total coal employed in the two lower layers, so as to secure the highest economy possible in this use of the fuel. Fire is then kindled in the straw or shavings; when the flames have communicated themselves to the cord-wood and lowermost layer of coal, and tongues of flame shoot out from the crevices in the sides of the heap, earth, previously loosed by a few turns of the plow about the heap, is rapidly spread over the entire heap, thus damping the draughts and retarding the combustion. Fig. 1 represents crudely this arrangement of the materials in the heap. Steam and smoke slowly escape during the first hours, but later the entire heap, includ-

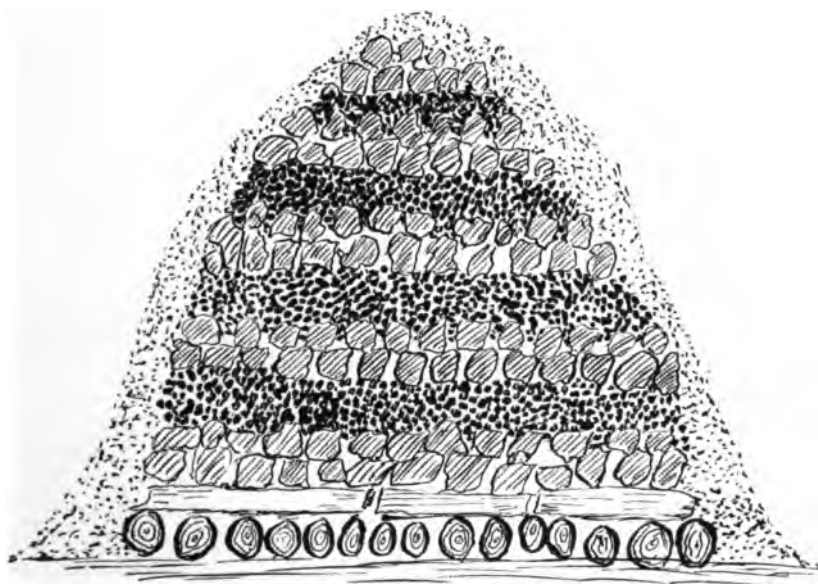


Fig. 1.

ing the outer covering of earth, is heated to a dull red glow. The burning goes on slowly for several days, the interior often being hot for several weeks. When the lower portion of the heap has reached an advanced state of calcination, a portion of the outer layer of lime sometimes slips down; if so, a fresh covering of earth must be promptly applied at the exposed point; otherwise, it will serve as a vent for the heat, and the top and other sides will fail of proper calcination.

In other localities the heap is covered with compact earth or sod before the fire is kindled, a few openings being left at the top, whereby the steam and smoke may escape; these openings are stopped as soon as the smoke has disappeared. Low* states that in England a compact wall is carefully built around the lower portion of the heap,

*Landed Property and Economy of Estates, p. 494.

with proper draught holes, and that the top is covered with turf or mud. "This," he says, "is an expensive method of burning, from the large quantity of fuel required; but from the more slow and gradual combustion, the lime is reckoned superior to that produced by other means." The quantity of fuel used in Centre county is roughly one ton of coal for each 100 bushels of lime, though a heap of 3,000 bushels is sometimes satisfactorily burned with twenty tons of coal; that is, the ratio of coal to lime ranges from 1:3.5 to 1:5, or, estimating on the basis of compact limestone, yielding about thirty bushels of lime to the perch, one ton of coal would burn from three and one-third to five perches.

Frasch* expresses the fuel requirement in other terms, viz: as 1.25 volumes of coal slack for each six volumes of stone.

KILN BURNING.

Of kilns there is a great variety in form and construction, but they may be grouped as belonging to one of three types:

A. Intermittent kilns, which require the complete calcination and removal of one charge before another can be introduced.

B. Perpetual kilns, from which the earlier calcined portions can be removed and fresh charges introduced while the burning is in progress. Of these there are two kinds:

a. Ordinary draw-kilns, in which the fuel and stone are introduced in alternate layers.

b. Flame-kilns, into which the stone is introduced, unmixed with fuel.

The *intermittent kiln* is not so frequently used as the draw and flame-kilns. It is sometimes employed where quite small quantities of lime are to be prepared with the use of wood as fuel. In such kilns, a dome of large pieces of limestone is built within the kiln, the inner walls of the kiln forming the abutment upon which it rests. During the forming of the dome, the stone is supported upon false work. Upon this dome the smaller stone is placed until the kiln has filled. Well-seasoned short-length wood is then set on end upon the grate, with which such kilns should be supplied, and kindled. The draught must be carefully regulated to ensure a gentle heat at the outstart, the fire being gradually increased during eight hours; otherwise, the quarry water in the large stone will be too suddenly converted to steam, rending them and possibly causing the arch to give way. The mass will then have settled about one-sixth and a crow-bar will work easily in it; the top of the kiln is then closed to confine the heat and complete the calcination of the upper layers, which requires ten to twelve hours more. With such kilns, the vertical distribution of heat is very uneven; hence, the kilns are made of rather large

*The Mineral Industry, VII (1898), 462 seq.

diameter and low, so that the bottom lime may not be overburnt and the top layers left "raw" or incompletely calcined.

Frasch* states that in such kilns from two to three volumes of hard wood are required for each volume of lime.

The *flame kiln* will be mentioned next. In this kiln the draw-arch is situated below and is independent of the fire-arch; and the latter is always provided with a grate and underlying shallow pit from which the ashes may be removed as necessary. Because of these peculiarities of construction, as well as for the purpose of securing a good draught, flame-kilns are usually given a relatively great height. Also, with the object of securing a more even firing, a single kiln usually has two or more fire arches opening into it from different sides, the fuel being delivered to an elevated platform, from which it is shovelled upon the grate as the burner thinks necessary. Many such kilns have, instead of a circular, horizontal cross section, one of oval form, the diameters being to each other approximately as four to six. Just about the level of the fire arches, the interior of the kiln is divided by a vertical wall, the top of which is narrowed to a sharp ridge, while the thickness of the wall increases toward its base in such manner that the interior of the kiln is divided into two compartments gradually curving out toward the draw-arches. All openings into the kiln are provided with doors, permitting the regulation of the draught. It is claimed for these (1) that they keep the lime free from impurities introduced in the fuel; (2) that the stone is more evenly burned; (3) that they are more convenient in working; (4) and that they are by far the most economical in their fuel requirements. The kiln should have such capacity as to hold from 1.75 to 2 times the amount of stone required for the daily yield of lime desired; the material is subject to the heat for twenty-four to forty-eight hours, and the lime is drawn every six to eight hours as the capacity of the "thimble," or receptacle for the burnt lime in the lower portion of the kiln, may make needful. The saving in fuel, at least when wood is used, is claimed to be at least three-sevenths of that required by intermittent kilns of the same output. Various manufacturers estimate that one cord of wood will burn from 60 to 110 bushels of lime, according to the quality of the fuel and stone and the conditions of burning. Frasn estimates that in the flame-kiln thirty-six to forty pounds of hard wood is required for each cubic foot of lime produced, and that in the Hoffman type of kiln, five pounds of coal slack is sufficient for this volume of lime.

The flame-kiln is, for the production of lime of a very pure, even quality and for economy of fuel, which reaches its highest importance in large operations carried on continuously, to be preferred to any other type of kiln.

*Loc. cit.

The ordinary *draw-kiln* is, however, far cheaper in construction, and for this reason, is commonly adopted where operations are not extensive and where the inclusion of some ashes from the intermixed fuel is not highly injurious to the use for which the lime is intended. There are many differences in the detail of construction of such kilns. The writer has seen in Somerset county, in a locality where suitable building stone for exterior walls is not readily obtainable, kilns whose outer walls and draw-arch are constructed simply of a crib-work of rough, notched logs; the interior walls were built up somewhat in the form of a peach basket, from thin sandstone found in the neighborhood, laid flat sides horizontal; between this inner shell and the crib work, clay was carefully tamped in forming a retaining wall for the lining of the kiln. Figures 2 and 3, after Gilmore, represent

Fig. 2.

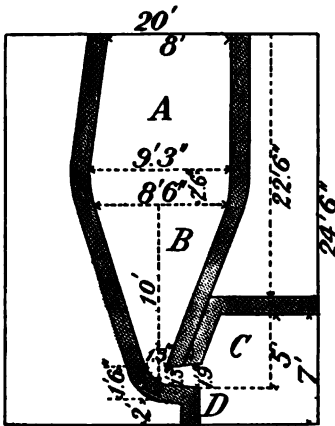
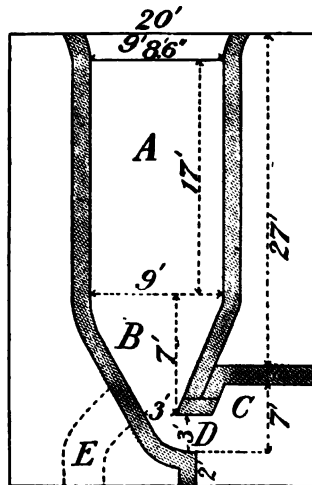


Fig. 2.



A—The body of the kiln; B—The bosh; C—The draw-arch; D—The door; E—Flue proposed by Shortlidge.

cross-sections of two common forms of draw-kilns; that represented by Fig. 3 being most frequently adopted in Pennsylvania. The outer walls are commonly built of limesone, sometimes of brick; instead of being vertical, as represented in the cut, it is preferred that they should have a slight batter. Since they have a tendency to crack and spread near the top after the kiln is heated, it is best to use, to strengthen the upper walls, several sets of iron tie-rods, crossing from side to side in the space between the inner and outer walls of the kiln; these may pass through horizontal, stout strips of timber on the outside to more effectually apply their retaining force; the rods should be secured at the ends by strong nuts, with large washers. The inner wall should be built of the best fire-brick if the kiln is intended for hard use; sometimes satisfactory substitutes for fire-brick are found in sandstone and hard clay-slate found in the

locality. The space between the inner and outer walls is commonly filled with well-tamped earth, which serves as a good retaining wall and as an excellent non-conductor of heat. It is often convenient to examine the glowing mass in the middle portions of the kiln and, in case it clogs, as sometimes happens, to be able to stir it down. Both advantages are secured by building into the kiln several two-inch iron tubes that pass from the exterior at convenient points, horizontally through the inner wall; when not in use they are closed by plugs, or caps; they admit a long iron rod by means of which the clogged lime can be poked and worked down. The opening from the interior of the kiln into the draw-arch should be closed by a door, so that the amount of air admitted at that point may be regulated.

By many lime burners the iron shell kiln is being adopted. This is a kiln whose body is formed from boiler iron, lined with fire-brick and supported upon iron pillars or upon an arch of masonry. It may either be simply enclosed within a wooden building or, for better prevention of loss of heat, within a wall of masonry suitably packed with broken stone or earth.

The late Col. Wm. Shortlidge, of McCalmont & Co., the owners of extensive lime kilns at Bellefonte, Pa., a lime manufacturer of many years' experience, mentioned to the writer the difficulty of regulating the draught so as to secure an even calcination, as one of the most serious objections to the ordinary, single arch draw-kiln. As a remedy, he proposed that a ring flue be constructed with its air inlets opening from the sides of the draw-arch and discharging through three or four vertical branches ending in stout iron gratings, about 9 inches by 12 inches, set at the same height in the sloping walls of the bosh of the kiln, so as to introduce air more uniformly to different parts of the kiln. He had already tried a modification of the old form of kiln in which this feature had been imperfectly introduced, and found it to result beneficially. The location of this flue with one of its branches is dotted into the vertical section, Fig. 3, at E. It would be desirable, the writer would suggest, to provide passages, closed with suitable doors let into the sides of the kiln, constructed at right angles to the axis of the draw-arch, for the annular flue will, in time, be stopped by the fine material that passes through the gratings and this dust must be removed to keep the draught in proper regulation.

The location of the kiln also has much to do with the draught. If the latter be poor, the burning is expensively slow. It is well known in regard to chimneys that if their tops be lower than the roof of the house or than the leafy tops of neighboring trees and the wind pass over the roof or tree top toward the chimney, a down-flow of air pours upon it and effectually checks the upward passage of the heated air from the cap or top. A similar checking of the draught

occurs in kilns situated in like manner with reference to a steeply sloping hillside. On the contrary, if the draw-arch face the prevailing wind and be provided with no regulating door, over-burning often occurs because of the occurrence of too fierce a draught.

So important are the points of regulation of draught, fuel proportion and quality of stone and coal to which a skilful burner closely attends, that, according to an experienced lime manufacturer, a flame-kiln of modern construction, with body of oval cross section, $4\frac{1}{2}$ feet \times $6\frac{1}{2}$ feet, and a height of 22 feet above the fire arch, which will, under most favorable conditions, yield 500 bushels of lime per diem, yields, in actual practice, with ordinary average stone and ordinary conditions, only 200 to 250 bushels. The same authority states that a kiln having been built, it is common experience to be obliged to materially modify arches, door-ways, etc., to adapt the draught qualities of the kiln to the particular movements of wind currents in the locality of this single kiln.

The variation in the quantity of coal required in this type of kiln ranges, according to computations based upon data given by Gilmore,* from one part to 2.25 to 7.2 parts of the burnt lime. Frasch** states that for three volumes of the stone, one volume of soft coal, one and one-half volumes of coke or three to four volumes of lignite is required. Magnesian limest† and cements require somewhat smaller proportions of fuel. Gilmore‡ states that 3,500 lbs. of anthracite coal is sufficient for 100 barrels of cement of 300 lbs. each, which is a ratio of one part coal to 8.6 parts calcined cement. The coal should be of a low ash content, if possible, to diminish the danger of "clinkering."

The best calcination occurs when the stone is broken into rather small pieces; this is especially true in burning impure limestones, which should be broken to less than six inches in diameter.

In the operation of the ordinary draw-kiln, kindling is placed upon the grate,§ covered with coal followed by stone, coal and stone alternating to the top of the kiln, which is often surmounted by a wooden crib by which its capacity is increased and the heat more fully utilized. In filling the kiln before the burning has begun, the lower coal layers are made unusually thick in proportion to those of stone, for reasons already suggested in discussing the burning in heaps; later, the normal proportions are maintained. Others prefer to fill the kiln one-half to two-thirds with raw stone, then adding a layer of fuel and subsequent layers of stone and fuel as in the charging during the burning; the fuel layer is in such case connected with

**Loc. cit.*, On Limes, Hydraulic Cements and Mortars, 1864, p. 141.

†Roscoe and Schorlemmer, *Treatise on Chemistry*, II, Part I, p. 190.

‡*Op. cit.*, p. 137.

§Many draw-kilns have the lower wall of the bosh terminate, as it approaches the door into the draw-arch, in a grating, below which is a shallow pit.

a core of kindling running from the draw-arch. The object of this arrangement is to secure a more uniform management of the heat; if, however, the coal layer is not ignited from the kindling, the expense of discharging and recharging the kiln is considerable.

STAGES OF BURNING.

According to H. Reid* there are two distinct stages in the burning of stone; the first, during which water is expelled and organic matter is destroyed; until this is completed, the indication being the disappearance of vapor readily recognized by the expert eye, the application of high heat is wasteful; the second stage is that of "decarbonation," and is completed when all the carbonic acid that can be profitably removed has been dispelled, which is accomplished at about the temperature of bright redness.

It is difficult to expel the last portions of carbonic acid. The stone burns more rapidly if it is somewhat moist. Many lime burners have been in the habit of using moist wood or of watering the stone with the object of developing steam to promote the expulsion of carbonic acid.

Frasch observes that fresh-quarried stone burns more perfectly than that which has been long exposed to the air and recommends periodic injections of steam or air. But Mahan† regards the practice as disadvantageous because of the increased fuel requirement.

BURNING IMPURE LIMESTONE.

Impure limestones are especially difficult to calcine uniformly; those containing sand often vitrify at a temperature not much above dull red heat, and the hard, glossy lumps left on cooling are not only of no use to the builder or farmer, but increase the difficulty of handling the other material.

When very impure clayey limestones are burned, the lime unites with the clay, which, as it occurs in the limestone, is insoluble in acids, and forms by union with it silicates that are completely dissolved by acids. Intimate mixtures of pure limestone and certain clays, when burned together, form similar silicates. The practice of clay-burning followed, a few decades ago, in many parts of England and Germany as a means of improving the soil, is believed to have owed its value to the formation in the burnt clay of similar silicates; clay deficient in lime, was not benefitted by burning.

TIME OF BURNING.

The length of time required for ignition in the draw-kiln is less than in the intermittent kiln. The lime will be partially drawn

*Portland Cement, p. 243.

†Civil Engineering, p. 35 seq.

every few hours so far as the burner finds it to have been satisfactorily calcined; no absolute time rule can be laid down.

According to Frascch a kiln of 1,200 to 1,400 cubic feet capacity will turn out 700 to 900 cubic feet per day of twenty-four hours, if ten to twelve charges be drawn during that period. The lime expands in volume from 20 to 25 per cent. during the burning, but retains the shape of the original stone. Pure lime should be burned rapidly, as it slakes better in such case, but if incompletely calcined it forms a basic lime carbonate and is "dead," or incapable of slaking. Compact limestone cannot be so rapidly calcined as the porous varieties, but yields a better lime.

As the lime is drawn, the major portion of the coal ashes can be thrown to one side, but some will remain admixed with the lime.

WEIGHT OF LIME.

The weight of a bushel of lime is much more variable than is commonly supposed. Lloyd* says "A ton of lime equals about 27 bushels;" that is, a bushel weight is 75 lbs. Roberts† also says, briefly, "75 lbs. of stone lime are sold for a bushel at the kilns at Union Springs, N. Y."

Cook‡ states that a bushel of good stone lime, unslaked, weighs 93 lbs.; of oyster-shell lime, 60 lbs.; of magnesian stone lime, 80 lbs. Legal weights for a bushel of unslaked lime have been established by several states as follows: In Ohio and Michigan, 70 lbs.; in Virginia, Georgia, Illinois, Iowa, Kansas, Nebraska and Colorado, 80 lbs.§. In Pennsylvania, the more commonly accepted bushel weight is 72 lbs.

In view of the range of these figures, it was thought of interest to inquire somewhat more particularly respecting the accurate weight of a struck bushel of the fresh-burnt limes sold in the State. The replies received from a number of lime burners and dealers are tabulated in the second column of the following table:

TABLE I.—Weight of a Bushel of Lime. (Struck Bushel; in Pounds.)

Quarry.	Fresh-burned.	Slaked.	Remarks.
Berks county:			
1. Near Bechtelsville, on Colebrookdale R. R., M. G. Oberholtzer, Prop'r,	82	.....	Solid, blue stone; 54 c. l., 44, c. m.
2. West branch of Maiden Creek, near Calcium, J. S. Pearson & Co., Prop'r,	78	40	Stone never analyzed.
3. Near Hest, Tulpehocken Twp., Jacob Shaffner, Prop'r,	78	40	Stone never analyzed, burns to a fine, white lime fit for building.

*Science of Agriculture, p. 119.

†Fertility of the Land, p. 306.

‡Report of the New Jersey State Agricultural Experiment Station, 1901, p. 21.

§Cf. Report, U. S. Dept. Agriculture 1899, p. 227.

TABLE I.—Continued.

Quarry.	Fresh-burned.	Slaked.	Remarks.
Blair county:			
4. Near Union Furnace, on main line P. R. R., Keystone Lime and Stone Co., Tyrone,	72	50	Slaked weight is for dry-slaked lime; analysis: c. l., 96; c. m., 2 per cent.
5. Stanfield Station, Hollidaysburg and Martinsburg Branch, P. R. R., John Manning, Hollidaysburg, Prop'r,	72	30	Slaked weight is air-slaked; analysis, 98 per cent. c. l.
6. Frankstown, on P. R. R., J. King McLanahan, Jr., Hollidaysburg, Prop'r,	72	.....	Analysis, 94 per cent. c. l., 3 per cent. c. m.
Chester county:			
7. Near Avondale, Phila. & Balto. Central R. R., Avondale Lime and Stone Co., Prop'rs,	80	35	Stone varies from a pure c. l. (fish egg) to a mica schist; stone burned has some magnesia, as it is the only kind in this quarry that will stay in lump during burning. Average composition, 70-80 c. l.; 15-25 c. m.
Franklin county:			
8. Near Williamson, on S. Penn. R. R., Isaac Lesher, Prop'r,	80	.....
Lancaster county:			
9. At Quarryville, I. Galen Lefevre, Prop'r,	75-80	.....
Lebanon county:			
10. One-half mile from Annville, Jno. A. Bachman, Prop'r,	{ a. 70-75 b. 75-80 }	26 or less.	a. soft-burned; b. hard-burned; slaked lime weighs half, or less than half as much as stone lime.
Lehigh county:			
11. At Fogelsville, A. W. Held, Prop'r,	100	.....	Analysis shows 90 per cent. c. l.
12. Near Egypt, E. D. Boyer, Catasauqua, Prop'r,	68-70	.....	Analysis shows 92 per cent. c. l., 1 per cent. c. m.; adjoins cement rock deposits.
Lycoming county:			
13. On Pine Creek, near Beech Creek R. R., J. Sebring, Jersey Shore, Prop'r,	72	50	
Monroe county:			
14. Boshardsville, Jno. P. Carner, Prop'r,	80	40	
15. Boshardsville, Peter M. Heller, Prop'r,	75	.....	Analysis, 94 per cent. c. l., 1.5 c. m.
16. Stormville, Allen Metzger, Prop'r,	70	.....
Montgomery county:			
17. Whitemarsh and Plymouth Twps. G. W. H. Corson, Plymouth Meeting, Prop'r,	70	.....	Screenings only sold for farm use.
18. Port Kennedy, Todd & Son, Prop'rs,	70	.....	Analysis, 53 c. l., 45 c. m., stone from Chester Valley dolomite. Sell screenings only for farm use; rest for building purposes.
Northampton county:			
19. 1½ miles South of Nazareth, Edw. Fehnel, Prop'r,	80	50-60	Stone is a slaty nature.
York county:			
20. Hendrix Station, Western Md. R. R., Bittinger & Eberly, Hanover, Prop'rs,	65	.....	Analysis, 83 per cent. c. l., 3 per cent. c. m., 4 per cent., carb. of potash.
Sussex Co., New Jersey:			
21. Montague, Geo. M. Cole, Prop'r,	80	about 40	
East Canaan, Conn.:			
22. Canfield Bros., Prop'rs; D. T. Gates, Agt., Mansfield, Tioga Co., Pa.,	100	.....	The lime is shipped to Penna. in barrels.

The wide range from 60 to 100 lbs. per bushel is thus reported for stone limes, the average for the twenty-three sorts being 76.2 lbs. There is no clearly distinguishable relation between the composition of the stone and the weight of the lime; compare, for example, Nos. 1 and 18 and Nos. 11 and 12, so that the porosity of the original stone is clearly the most influential factor, to which no doubt the conditions of burning add another potent influence.

Thus, Frasn notes that a given volume of lime from a draw-kiln weighed 55 lbs., but the same volume of lime produced from the same stone by calcination in a Hoffman flame-kiln weighed only 50 lbs.

SLAKING OF LIME.

The general phenomena of *slaking* and its chemical nature have already been mentioned. Limes exhibit, according to the composition of the rocks from which they have been prepared and the manner in which they have been burned, differences in regard to slaking so great that they constitute the basis of the most commonly accepted classification of limes and cements.

GILMORE'S CLASSIFICATION.

Gilmore* has given the most satisfactory classification for our present purposes. He divides limes and cements into five distinct classes, as follows:

1. Common, or fat, limes: Contain usually less than 10 per cent. of impurities. In slaking, swells to two to three and one-half times its original volume; with sufficient water, forms a homogenous paste, very soluble in water; the paste will not harden under water or under the air pump, but on standing in the air, whereby calcium carbonate and crystals of calcium hydrate are formed. The paste shrinks greatly in hardening; hence, the need for addition of sand in making mortar.

2. Poor, or meagre, limes: Contain 10 to 25 per cent. of impurities, sometimes as much as 39 per cent. Slakes sluggishly, unevenly and with much less heat and swelling than fat lime. Paste less perfectly soluble. Silica is present chiefly as sand.

3. Hydraulic† limes: Seldom contain 35 per cent. impurities. Slake, but with little disengagement of heat or vapor and swelling rarely more than one-third of the original volume. They are subdivided as follows:

a. Lime slightly hydraulic; impurities, 10-20 per cent.; stiff paste, hardens under water in fifteen to twenty days.

*Op. cit., p. 69 seq.

†By *hydraulicity* is meant the property of setting or hardening under water.

b. Hydraulic limes; impurities, 17-24 per cent.; stiff paste hardens under water in six to eight days.

c. Limes eminently hydraulic; impurities, 20-35 per cent.; paste sets under water in one to four days.

The swelling of these sub-classes is the less as they are more hydraulic in property.

4. Hydraulic cements; impurities, 36-60 per cent.; do not slake or swell with water; some set in one to four minutes at 65 degrees Fahr., others in as many hours.

Intermediate between the latter are certain clayey magnesian limestones which make good cements when underburnt, but when completely calcined, yield a paste that sets rapidly, but later cracks, softens and crumbles under water.

5. Natural puzzuolonas, chiefly composed of silica and alumina, besides other bases, but not more than 10 per cent. of calcium carbonate; these impart hydraulicity to fat lime paste even without calcination, which increases the quickness of setting but not the strength of the resulting cement.

Concerning hydraulic cements: It is generally accepted that these materials usually owe their properties to certain silicates of alumina, lime and other bases. These silicates may be formed by the action of moist lime upon natural puzzuolanas (clays of volcanic origin) or upon burnt clay of other origin, or they may be formed when clayey limestones are calcined. In the last case, it is not simply the amount of clay, but also the uniform distribution through the stone that affects the quality of the cement. The action of setting in a cement is considered to be similar to that in plaster of Paris. Gypsum, the crystalline sulfate of lime, contains, combined in the crystal, nearly 21 per cent. of water; in preparing plaster of Paris, the gypsum is roasted, or "boiled," as it is technically termed, to remove this water; in this process, the crystals fall to pieces, forming a dry, white powder. When this powder is mixed with a proper proportion of water, the latter is taken up by the plaster of Paris and crystals are again formed in a short time; the soft paste has "set," or hardened. It is owing to the fact that the volume of the paste is not materially changed in the setting that plaster of Paris is so largely used in making casts or impressions.

Now, in like manner, it is believed, the anhydrous silicates formed in the cement take up, when moistened, the water necessary to crystal formation and "set," and since the crystals thus formed are little dissolved by water, the cements may be used in constructions that are exposed to the action of water.

MAGNESIAN LIMES HYDRAULIC .

Examination by Vicat and Rogers* show that in limestones in which the carbonate of lime is substituted by 25 per cent. or upwards

*Cf. Mahan, Civil Engineering, pp. 21-22.

of magnesium carbonate (nearly corresponding to 12 per cent. of magnesia), distinct hydraulicity may appear in the presence of no more than 5 per cent. of impurities, including only 3.6 per cent. of silica and alumina. The conditions of hydraulicity in limes derived from such stone are not well understood. Frasch states that the presence of only 10 per cent. of magnesia in the stone leads to the formation of a lime that is gray and short, or of very imperfect slaking quality, and that the presence of 25 to 30 per cent. renders the lime entirely unfit for burning.

CHEMISTRY OF SLAKING.

The *slaking of lime* requires consideration in this connection. It has already been explained that the chemical change that occurs in this process is essentially a conversion of the calcium oxid to calcium hydrate by the chemical union with water; 56 pounds of the dry oxid unite with 18 pounds of water to form 74 pounds of dry hydrate. Unlike the change that occurs when plaster of Paris or hydraulic cement sets, there is, in this case, a great development of heat, sufficient in some cases to boil water and, it appears in some cases, where the heat is prevented from rapid escape, that the temperature may rise to the point at which wood ignites. Frasch notes the observation of a temperature of 150 degrees C. (302 degrees Fahr.) in slaking lime and states that the storage of burnt lime in barrels is especially conducive to the outbreak of fire.

Whether by the formation of crystals of calcium hydrate or by the mere expansive action of the steam generated, the process of slaking pure lime is attended by large expansion. Even pure lime is subject, however, to many variations in the products of slaking, according to the conditions under which the process is performed. The mortar-maker and the plasterer are obliged to pay serious attention to these points. In this connection the few facts of chief importance in handling limes intended for agricultural use may be noted.

Limes that have advanced in slaking sufficiently to have become hot and are then chilled by sudden cooling, as by stirring or by the addition of fresh portions of cold water, will not fall to a fine powder nor form a smooth paste, but will, in considerable proportion, assume a coarse granular form. If, however, one-third of the requisite amount of water is first added, and then, just as soon as the lime has swelled to the utmost, the remainder be poured on, Frasch claims that a superior product will be obtained. The use at one time of more than the requisite amount of water also results in the formation of granular lime, as is often observed in the drowning process, commonly employed in preparing white-wash. If fresh-burned lime is piled in small heaps of three or four bushels and covered with several inches of fresh, moist soil from an upturned furrow slice, it

will take from the earth all the water needed for slaking to a fine powder. If, however, heaps of 25 to 200 bushels are to be slaked, it is well, after covering with a heavier layer of moist soil, to make small openings into the center of the mass by use of a crow-bar and to pour in water through these openings. The steam formed will perfectly slake the lime in all parts of the heap.

WEIGHT OF SLAKED LIME.

Concerning the volume occupied by water-slaked lime, Dr. Geo. E. Cook* states that 1 bushel of good stone lime weighing 93 lbs., slakes to nearly 3 bushels, each of about 45 lbs. weight; that a bushel of oyster-shell lime weighing 60 lbs. forms somewhat over 2 bushels of slaked lime, each of about 40 lbs. weight, and that 1 bushel of magnesian lime, weighing 80 lbs., yields 2 bushels of slaked lime, each of 40 lbs. weight. It is evident, however, that the conditions of burning, purity, etc., of the lime and the conditions of slaking also greatly modify the changes in volume occurring during slaking. Thus, Gen. Totten† states, as the result of many trials that one volume of quick-lime yields, when slaked with one-third volume of water, 2.27 volumes of powder; with two-thirds volume of water, 1.74 volumes powder; with three-fourths volume of water, 1.81 volumes of powder; and with an equal volume of water, 2.06 volumes of powder.

AIR-SLAKING.

There is another process of slaking to which attention must, in this connection, be especially directed, that of *air slaking*. When caustic lime is exposed in lump to the action of the air it gradually slakes and falls to powder as a result of the absorption of moisture from the atmosphere. At the same time with the absorption of moisture, carbonic acid is also taken up and more or less of the lime returns to its former state of combination as carbonate, though now in a finely powdered form, instead of compact as in the stone. Consequently, such lime is possessed of less causticity. Gilmore‡ says that while in a layer of ten to twelve inches thickness, some limes completely air slake in twenty to twenty-five days, others would require as many weeks and some a year. In mortar, the carbonate forms first on the outer surface and then more slowly in the interior. Vicat§ states that this layer is only .10 to .12 inches deep at the end of a year, and Reid|| further asserts that analyses of mortars taken from buildings erected

*Loc. cit.

†Gilmore, *Lime, Hydraulic Cements, etc.*, p. 124.

‡Op. cit., p. 122.

§Gilmore, *Op. cit.*, p. 127.

||Op. cit.

more than a century before, still show that a portion of the lime in the interior of the mortar has never been carbonated, the solidification or "setting" of the mortar being more largely due to the crystallization of the calcium hydrate than to its conversion into the solid carbonate.

Lime exposed, in small heaps in the field, to the action of heavy rains and of the air, falls to a powder more or less coarse, containing a large proportion of carbonate. Even when covered with a thin layer of earth, some carbonate is formed. In a heap of pure lime thus slaked, Voelcker* found over 15 per cent. of calcium carbonate.

H. J. Wheeler† states that dry, fine, air-slaked lime, such as has been bought from time to time by the Rhode Island Experiment Station, has been found to contain but 68 to 75 per cent. of the caustic lime (calcium oxid).

The practice of covering during slaking is much to be preferred and, where possible, that of slaking in one large heap, rather than in a number of small piles. At all events, lime should be exposed in uncovered heaps no longer than is necessary for the slaking to a fine powder, after which it should be promptly distributed and worked into the soil.

The change in volume during air-slaking is even greater than that which is caused when the lime is slaked by sprinkling. Reference to the table giving the bushel weights of fresh-burned and slaked limes produced or on sale in Pennsylvania shows that they range from 30 to 60 pounds, averaging over 40 pounds.

TESTS FOR QUALITY OF LIMESTONE

If it be desired to make some test of limestone to determine its quality, spalls should be taken from a freshly exposed surface of the stratum to be tested; these should be broken fine and a carefully weighed or measured portion heated with a dilute acid. The acid used may be muriatic (hydrochloric), nitric or acetic; a liberal amount of good strong vinegar may be used. The heating should be carried on in a porcelain-lined or granite-ware cup. If carbonate of magnesia be present in large proportion, the stone will not bubble or effervesce strongly upon the addition of cold acid, as it would were the stone composed chiefly of carbonate of lime with insoluble impurities only. The acid solution may be carefully poured off after heating. The insoluble residues left in the cups by different strata can then be roughly compared, and their nature as clay or sand noted.

Or, larger pieces of the stone may be burned in a coal fire; the calcined stone, better the inner portion of it, may then be treated with water to note its slaking properties, the liberation of high heat, great swelling and final formation, if the water be added in proper propor-

*Oy. Lloyd, *Science of Agriculture*, p. 114.

†R. I. Agr. Exp. Sta. Bull. 46, p. 106.

tion, of a fat lime-paste, all giving evidence of the purity and high value of the stone.

COST OF LIME IN PENNSYLVANIA.

The cost of lime in different parts of Pennsylvania varies greatly, according to the distance of railroad transportation chiefly. The expense of home-burning is variously estimated: One Bedford county correspondent estimates it at 2 to 3 cents per bushel, or 4 to 5 cents per bushel, counting the cost of the labor; a Clarion county correspondent at 5 cents, labor included; a Huntingdon county correspondent at 3½ cents, items included not being specified; a Jefferson county correspondent, at 4 cents.

Lime bought from dealers is quoted in different counties as follows:

Adams,	6 to 11 cents per bushel.
Armstrong,	6 to 8 cents per bushel.
Bedford,	5 to 8 cents per bushel, as to quantity and quality.
Berks,	6 to 10 cents per bushel.
Bucks,	11 to 13 cents per bushel.
Butler,	Stone, 20 cents; slaked, 8 cents per bushel.
Cambria,	At local kilns, stone, 9 to 10 cents; slaked, 6 to 8 cents; shipped, 9 to 12 cents in carload lots.
Cameron,	30 cents per bushel.
Carbon,	8 cents per bushel.
Centre,	5 to 8 cents per bushel.
Chester,	6 cents for "fell" lime; 10 cents for small-size fresh lime.
Clinton,	8 to 9 cents for "run of the kiln;" 10 cents, screened.
Columbia,	6 to 8 cents per bushel.
Cumberland,	7 cents per bushel.
Dauphin,	6 to 7½ cents per bushel.
Elk,	14 to 15 cents.
Forest,	24 cents per bushel, slaked.
Franklin,	7 to 8 cents per bushel.
Fulton,	8 to 10 cents per bushel.
Greene,	4 cents at kiln.
Huntingdon,	5 to 7 cents per bushel; slaked, 3 cents.
Indiana,	5 to 10 cents.
Jefferson,	6 to 7 cents.
Juniata,	5 to 7 cents.
Lackawanna,	10 to 12 cents.
Lancaster,	6 to 9 cents.
Lawrence,	10 cents.
Lebanon,	7 cents; very pure, 9 cents.
Lehigh,	7 to 9 cents.
Luzerne,	6 to 10 cents.

Lycoming,	6 to 10 cents.
McKean,	36 to 54 cents (\$10 to \$15 per ton).
Mercer,	6 to 10 cents.
Mifflin,	6 cents.
Monroe,	6 to 9 cents.
Montgomery,	7 cents.
Northampton,	6 cents for soft slate-stone lime; 7 to 8 cents for purer lime.
Northumberland, ..	5 to 8 cents.
Perry,	5 to 9 cents.
Pike,	12½ cents.
Schuykill,	9 to 12 cents.
Snyder,	7 cents; \$5 per car load.
Somerset,	6 to 9 cents.
Susquehanna,	9 to 11 cents; \$3 per ton.
Tioga,	28 to 35 cents per bushel, or \$1 per barrel.
Union,	5 to 7 cents.
Venango,	6 cents.
Warren,	Stone lime, 75 cents to \$1.00 per barrel; slaked, 50 cents per barrel.
Wayne,	12 to 13 cents, delivered at railway.
Westmoreland, ...	3½ to 10 cents.
York,	9½ to 12 cents.

LIME IN PLANTS.

LIME ESSENTIAL TO PLANT LIFE.

Mineral matter is absolutely necessary to the growth of plants, and every organ of the plant leaves, when it is carefully burned, a larger or smaller proportion of ashes. Among the many materials found more or less commonly in these ashes, there are several that are always present and that have been found by careful investigation to be, each of them, absolutely indispensable to the full development of all plants, being incapable of complete substitution by other ingredients. Such are lime, magnesia, potash, iron and phosphoric and sulfuric acids, and possibly soda and chlorin in very minute quantities.

QUANTITY OF LIME IN PLANT ASHES.

Space will not permit a presentation of the composition of various plant ashes to fully show the large proportion in which lime enters

them. In the following table, compiled by Johnson,* a general statement is given of the composition of the ashes of the ordinary crops as they are at time of harvest, and will suffice to exhibit the more important differences in their lime content:

TABLE II—Composition of Ashes from Principal Classes of Crops.

	Potash and soda.	Magnesia.	Lime.	Phosphoric acid.	Silica.	Sulfuric acid.	Chlorin.
CEREALS—							
Grain,	30	12	3	46	2	2.5	1
Straw,	12-27	3	7	5	50-70	2.5	2
LEGUMES—							
Kernel,	44	7	5	35	1	4	2
Straw,	27-41	7	25-30	8	5	2-5	6-7
ROOT CROPS—							
Roots,	60	2-9	6-12	2-3	1-4	5-12	2-9
Tops,	37	2-16	10-35	2-3	3	6-12	5-17
GRASSES—							
In flower,	33	4	3	3	25	4	5

These figures show clearly that the straw is, weight for weight, richer in lime than the grain, and the tops of the root crops richer than the roots; also, that the straw of legumes, such as peas, beans and clover, is richer in lime than that of the grasses and common cereals.

LIME REMOVED BY CROPS.

Taking into account the average amounts of ash in the various farm crops and the composition of the several ashes, using American analyses for the computation of the several averages, where they are available, the quantities of the various plant constituents that are removed from the soil by the respective crops, are as follows:

*How Crops Grow, 1890, p. 171.

TABLE II—Weights and Composition of Ordinary Crops in Pounds per Acre.

	Weight as harvested.	Nitrogen.	Phosphoric acid.	Potash.	Lime.	Magnesia.	Iron oxid.	Sulfuric acid.	Soda.	Chlorin.	Silica.
Meadow hay (1½ tons),	3,000	37.8	12.6	50.9	30.4	12.1	3.0	9.9	7.0	11.8	54.8
Timothy hay (1½ tons),	3,000	28.3	23.0	62.9	14.2	5.3	1.5	5.1	3.2	9.2	57.1
Clover hay (2 tons),	4,000	73.40	22.4	75.0	51.1	28.3	2.5	7.5	4.6	8.8	61.3
WHEAT—											
Grain (28 bus.),	1,500	28.3	12.4	8.2	0.9	2.2	0.2	0.1	0.6	0.1	0.5
Straw,	2,500	13.6	5.8	15.6	7.0	3.0	0.7	2.0	1.7	2.0	81.9
	4,000	41.9	18.2	24.8	7.9	6.2	1.0	2.1	2.3	2.1	83.4
RYE—											
Grain (30 bus.),	1,880	28.5	14.8	10.0	0.9	2.5	0.4	0.4	0.5	0.1	0.4
Straw,	2,000	9.6	5.4	18.7	6.8	2.6	1.6	2.5	1.4	1.8	40.8
	3,880	38.1	20.2	28.7	7.7	6.1	2.0	2.9	1.9	1.9	41.2
OATS—											
Grain (50 bus.),	1,800	20.2	11.4	8.0	1.6	2.2	0.5	0.8	0.7	0.4	17.4
Straw,	2,100	12.4	6.8	39.4	9.5	5.0	1.8	4.4	4.5	8.0	63.8
	3,700	42.6	17.7	47.4	11.1	8.2	2.1	5.2	5.2	6.4	81.3
BARLEY—											
Grain (50 bus.),	2,350	48.6	19.2	11.7	1.4	4.8	0.6	1.0	1.2	0.5	14.2
Straw,	2,800	13.7	5.4	29.6	9.3	3.2	1.4	4.9	4.5	4.1	64.9
	5,150	60.3	24.6	41.3	10.6	8.1	2.0	5.9	5.8	4.6	79.1
CORN—											
Kernel (50 bus.),	2,800	46.1	16.40	16.80	0.80	5.60	0.80	0.80	0.40	0.80	0.80
Cobs,	700	2.7	0.04	0.42	0.02	0.02	0.01	0.01	0.24	.....	.....
Stover,	2,800	14.0	3.74	3.83	11.80	5.98	3.04	5.75	1.15	.....	41.17
	5,800	62.8	26.18	15.04	12.32	11.61	3.85	6.06	1.79	0.80	41.97

POTATOES— Tubers (500 bua.),	14,000	47.0	13.9	67.3	3.9	5.5	1.2	7.3	2.3	2.9	2.2
	4,500	51.1	6.3	15.3	22.1	14.3	2.5	5.4	2.0	2.7	6.7
	Haulm,										
SUGAR BEETS— Roots (20 tons),	13,500	62.1	35.7	84.0	81.1	10.7	3.7	13.7	5.3	7.6	9.0
	40,000	115.2	26.2	109.9	12.6	15.3	2.4	8.7	13.5	9.9	4.7
	20,000	76.0	23.3	129.0	99.3	55.6	2.6	26.0	67.5	41.6	49.9
MANGELS— Roots (25 tons),	60,000	191.2	43.5	223.9	111.8	71.9	5.0	24.7	98.0	51.5	54.6
	15,500	113.0	29.4	189.1	12.9	37.6	2.8	10.4	56.1	24.2	7.1
	Tops,	51.3	16.7	79.1	27.5	24.6	3.6	14.5	60.1	41.2	9.3
TURNIPS— Roots (20 tons),	63,500	162.3	46.1	269.2	40.4	62.2	6.2	24.9	106.2	75.5	16.4
	40,000	70.4	33.7	126.2	32.3	11.9	2.5	24.0	39.9	15.4	5.7
	11,000	49.3	13.2	62.4	69.5	7.1	2.9	17.0	17.1	13.3	6.9
SWRDES— Roots (15 tons),	51,600	130.2	51.9	130.6	91.8	12.3	5.4	51.0	47.0	33.7	12.6
	22,000	61.4	13.4	69.0	21.5	7.4	.....	39.8	24.3	7.4	2.4
	4,800	23.6	4.9	16.7	23.1	2.4	.....	8.9	9.4	8.5	3.7
Cabbages (20 tons),	26,800	99.0	22.3	85.7	44.6	9.3	.....	48.0	24.2	15.9	7.1
	40,000	133.8	42.6	199.2	36.2	21.6	2.7	76.2	63.2	46.1	4.7
	22,500	63.3	22.4	62.5	42.7	8.7	4.2	10.6	4.6	4.6	13.9
Tobacco (leaf),	1,500	58.3	10.3	67.3	32.4	17.0	4.5	14.1	7.4	15.5	13.4

DISTRIBUTION OF LIME IN THE PLANT.

The kinds and quantities of ash constituents in any given part of the plant are not constant, but vary not only with the species and variety of the plant, and with the conditions under which it grows, but also in the same plant during its development. A number of interesting observations have been made upon the movements of lime in various plants, of which a few may be cited.

Of the various organs, the leaves are richest in lime, except in the case of trees, whose bark surpasses the leaf.

The investigations of Arendt* show 16.7 and 17.2 per cent., respectively, in the lower and upper leaves of the oat plant, while the stem contains 3.6 to 8.6 per cent., and the ears 7.3 per cent. The older leaves usually contain far more than those of less maturity. Thus, Bretschneider,† comparing the inner, or younger, leaves of the sugar beet with the outer, or older, leaves, found in the innermost only 4.7 per cent., as compared with 24.2 per cent. in the outermost. Another of many illustrations of this fact is found in the case of the chestnut. Fliche and Grandeaup‡ found in leaves taken May 1, 18.41 per cent. of lime, and in others taken October 12, 49.50 per cent., while the percentage of magnesia differed little, and those of potash and phosphoric acid were greatly diminished in the older leaves.

Studying the changes that occur during the development of the grain of oats, Arendt§ obtained results indicating a transfer of lime with potash from the grain as it matures, while magnesia and phosphoric acid are transferred in large quantity from the leaves to the grain.

Lime and magnesia, which bears so much resemblance to it in its chemical reactions, are also very differently distributed in the grain of cereals, as shown by the analyses of bolted wheat flour and bran, from which it is clear that the inner portion of the endosperm from which the finer flour is prepared, contains most of the lime, while magnesia occurs chiefly in the bran. Owing to the relatively small quantity of lime in the seed, as compared with that in the leaf, it is not surprising that Boehm,|| Von Liebenberg,** Dehérain and Bréal†† have discovered that under ordinary condition of germination, lime is the first ash constituent required to be supplied from the soil in order that the processes of vegetation may be completed.

In the sprouting of the tubers of potatoes, Kellermann‡‡ found, on the other hand, that while the total ash, potash and phosphoric

*Cf. Johnson, *How Crops Grow*, 1890, p. 171.

†Ib. p. 172, from Hoff. *Jahresbericht*, 4, 89.

‡Ann. chim. phys. (5) 8, 500; Dehérain, *Chimie Agricole*, 1892, p. 156.

§Op. cit., p. 237.

||Ann. Agron., 1, 470.

**Ib. 8, 58.

††Ib. 9, 127.

‡‡Ib. 4, 615.

acid in the tubers steadily decreased for fourteen weeks, the quantity of lime increased five fold, being taken up from the soil and held in the old tuber in the form of calcium oxalate, the continuous secretion of oxalic acid and formation of the oxalate accounting for the absorption of the lime.

Desbarres,* in studying the development of new wood of the sumac, found little change in the composition of the ash.

COMPOUNDS OF LIME IN PLANTS.

The condition in which it exists in the plant, varies with the species and the circumstances of its growth. When the plant is young and the lime is not present in excess, it is largely combined with the acids characteristic of the species in the form of an acid salt, present in solution in the sap. The acid malate of lime sometimes occurring so abundantly in maple sap and known to maple sugar makers under the names of "sand" and nitre," is an interesting example of this kind of compound.

LIME SOMETIMES PRESENT IN EXCESS.

When a soluble salt of lime with a mineral acid is taken up in excess by the plant, a portion of it may be excreted through the leaf, to be washed off by the rain, as was observed by Saussure† in the case of calcium chlorid upon the leaves of the cucumber.

Certain rather difficultly soluble compounds of lime and albuminoids are found in grains and as calcium carbonate unites with some of the group of organic substances of which starch, wood and sugar are members, it is believed by some investigators that similar chemical compounds occur within the plant.

When lime is present in large quantities, much of it is present in the form of saline encrustations or in crystals. Potato leaves often contain considerable quantities of solid calcium carbonate, which is also often found in wood and bark. In dense teak wood,‡ concretions of calcium phosphate are often found, while 80 per cent. of the dry matter of *Cactus senilis* is composed of calcium phosphate and oxalate. The leaves of the walnut, the leaf stem of the rhubarb and the beet root often afford beautiful specimens of crystalline calcium oxalate. Sachs found in the root of the young bean, crystals of calcium sulfate. The *Saxifraga crustata*, a low European plant found in lime soils, is covered by a scaly encrustation of calcium and magnesium carbonates, which Unger§ found to proceed from granular expansions on the margin of the leaf directly connected with the sap ducts; in soils poor in lime, the encrustation does not appear.

* Dehérain, *Chimie Agricole*, p. 61.

† *Recherches sur la Veg.* p. 265; Johnson, *How Crops Grow*, p. 203.

‡ Cf. Johnson, *How Crops Grow*, pp. 204, 206.

§ *Sitzungsber. Wien. Akad.*,

Berthier* makes the interesting observation that rye, which grows well on granitic and siliceous soils, contains, in the ash from the mature straw, calcium only in the form of phosphate, while the ash of barley, which grows upon such soils only after they have been limed, contains not only as much calcium phosphate, but also a percentage of calcium carbonate much larger than that of the phosphate.

USES OF LIME IN THE PLANT.

The functions performed in the plant by lime are not clearly defined. That it is useful in neutralization of plant acids and in their removal, when in excess in the sap, in the form of insoluble, neutral salts, has already been made apparent. Grübler† has observed the occurrence of both calcium and magnesium in the aleurone grains of seeds, where they occur as soluble, crystallizable compounds with the albuminoids, whose diffusibility they thus promote.

There is evidence to indicate that, while lime is not essential to the formation of starch in the leaf, it is useful in the normal formation of cellulose. Boehm‡ and Von Raumer§ made a series of observations upon the germination of the scarlet runner (flowering-bean, *Phaseolus multiflorus*.) Germinating it, keeping its roots in pure water and its leaves in the darkness, the young shoots are seen to develop without green color, but perfect in form, for a number of days, when, suddenly, there appears just below the terminal bud, a discoloration, and the stem wilts, withers and dies; yet the cotyledons, or seed lobes, are still unexhausted of their supply of starch, the reserve building material from which the wood of the cell walls is derived. If, however, instead of placing the roots in pure water, they be inserted in a dilute solution of any lime compound (except the chlorid), the plants maintain the stem development until the starch in the seed is completely exhausted. According to Boehm, carbonate of magnesia, instead of being able to replace lime for this purpose, is positively poisonous. Von Liebenberg|| has extended these observations with similar result to the seeds of a number of plant species.

On the other hand, Dehérain and Breal,** observed that while lime is beneficial to normal germination and indispensable to normal stem development at the ordinary temperatures of germination in the soil, the seed is able, at slightly elevated temperatures (86 degrees to 95 degrees Fahr.), to continue a healthy stem development until the starch in the seed has been exhausted, without the presence of any lime except the small amounts already present in the seed. Storer††

*Dehérain, *Chimie Agricole*, 153-3.

†Johnson, *How Crops Grow*, 1890, p. 216.

‡Jb. Ag. Chem., 1875-6, I, 255; Ann. Agron. 1, 470.

§Vers. Stat., 29, 261.

||Ann. Agron., 9, 127.

**Ann. Agron., 9, 53.

††Agricultural Chemistry, 1892, II, 407.

notes, further, the fact that cellulose formation is carried on in certain fungi, such as beer-yeast, in the entire absence of lime, the fact having been established by the researches of A. Mayer and Cohn; Storer, therefore, suggests that lime is indispensable for the proper formation of leaves, rather than for that of cellulose in general. Heinrich,* however, inclines to the opinion of Boehm, and notes the almost invariable incrustation of the cell membranes with lime compounds, an incrustation which becomes thicker as the cell grows older, especially in the case of woody cells. Loew† and Bokorny‡ regard it as playing an important part in the chlorophyll granules and of the nuclei, or reproduction centers, parts of the highest importance in the life of the plant.

EFFECT UPON FORM OF PLANTS.

R. Heinrich§ notes that lime has a marked influence upon the external forms of vegetation; when lime is abundant in the soil, the internodes between the leaf axils are shorter and thicker, and the plants set more abundant and vigorous stalk organs and tend to heavier fruiting, whereas upon soils deficient in lime, plants shoot up in slim stalks and, though often blooming abundantly, set fruit deficiently.

E. W. Hilgard|| speaking of the character of the growths of the several species of oaks ("post," "black jack," "scarlet" and "white") upon strong and upon light soils in Mississippi, notes that upon the former soils, the growths are sturdy, thick-set, with short, stout branches and dense tops; while on the poorer soils the growths are more slender, often very crooked and knotty, with slender branches and open or tattered top.

CALCIPHILE AND CALCIFUGE PLANTS.

It has been noted that certain plants, such as the sugar beet and common red clover, flourish particularly well in soil containing abundance of lime; hence, such plants are called "calciphile," or lime-loving. Others, such as the sorrel (*Rumex acetellosa*), sea pine, chestnut and lupin, either grow with less luxuriance upon lime soils than upon soils deficient in this ingredient, or are injured or absolutely destroyed by liming. Such plants are called "calcifuge," or lime-avoiding. The growth of such plants as indicative of the nature of the soil and in its relation to the agricultural application of lime will be considered in another connection. It is of interest here to note that the calcifuge plants are not devoid of lime, but often contain large amounts of it. Thus, the ash analyses of the sugar beet,

*Mergel u. Mergeln, 1894, 4.

†Flora, 1892, Heft. 1.

‡Bot. Centralbl., 63, 1.

§Mergel u. Mergeln, 1894, p. 4.

|| X Census, Vol. V, 226.

compiled by Wolff, show in the ash of the root 6 per cent., and of the top 20 per cent. of lime, while those of the lupin show in the seed ash 7.5 per cent. and in that of the straw about 23 per cent.; that is, the proportion of lime in the ash of the calcifuge plant was actually the larger. If, in like manner, a comparison be made between the ashes of the chestnut and of the white oak, the latter growing especially well upon calcareous soils, it is found that the ashes of the chestnut contain, the bark 47 per cent., the wood 49 per cent. of lime, and those of the white oak, the bark 52.73 per cent., and the wood 29.85 per cent. of lime.*

Fliche and Grandeauf have made an interesting study of the composition of the sea pine. This tree prospers only on soils quite poor in lime. Analyses were made of twigs (1) taken from a tree growing on a soil containing .05 per cent. of lime in the surface, and 0.20 per cent. in the sub-soil; (2) from a tree growing in a soil containing in the surface 3.25 per cent., and in the sub-soil 24.04 per cent.; (3) for comparison, the composition of the ash of the Austrian black pine, growing well on lime soil, was determined; the percentages of lime were (1) 40.2, (2) 56.1, (3) 49.1; that is, the ash of the calcifuge plant contained about as much lime as the calciphile when both grew upon soils best adapted to their normal development. When the sea pine was grown upon a calcareous soil, its content of lime was abnormally increased, and, curiously, the percentage of potash was reduced two-thirds; the loss of vigor is probably due to the deficiency of potash. Bernard,† in his studies upon the vine, which, especially the native vines of France, is subject to a very destructive disease manifest through the leaves and termed "chlorosis," states that it is caused by excess of lime in the soils. When the grape leaves are examined, they appear to contain numerous crystals of calcium oxalate, and, like other calcifuge plants, show a similar tendency to throw out of circulation the excess of lime in their tissues. The juices of chlorotic grapes also appear less acid than normal and sometimes even clearly alkaline. When the chlorosis is cured, the crystals of calcium oxalate disappear.

LIME IN SOILS.

COMPOUNDS OF LIME PRESENT.

In earlier paragraphs treating of the formation of limestones, the fact was noted that lime is one of the rock substances more easily

*Cf. Handbook of Exp. Station Work, 1892, p. 411.

†Ann. chim. phys., (4), 29, 332.

‡Le Calcaire, 1892.

taken into solution when rocks weather or decay. It forms somewhat readily soluble compounds with chlorin, nitric, sulfuric, carbonic acid and with certain organic acids; less soluble with other organic acids, phosphoric acid and, in certain hydrous double compounds, with silica and alumina, while its anhydrous compounds with silica are the most insoluble combinations into which it enters.

Considering the great variety of mineral substances from whose weathering and pulverization soils have been formed, with the modifying influences of the varying nature of the surface of the country and the varying extent to which living organisms have been active in the soil formation, it is not surprising that soils should exhibit a very wide difference in their content of lime.

PROPORTION IN VARIOUS SOILS.

The following list of soils, with the proportion that they contain of lime soluble in hydrochloric acid, serves to exhibit the great differences:

TABLE IV—Percentage of Lime in Various Soils.

Kind of Soil.	Lime. Per cent.
1. Prairie soil from North Dakota, .....	.35 to 3.30
2. Virgin soil from Walla Walla; fertile, sandy, from basaltic rock,	1.34 to 3.19
3. Muck, from Union Pier, Mich., .....	.97
4. Heavy prairie swamp, with clay subsoil; yields large crops of hay, fair wheat, poor corn,	1.23
5. Subsoil corresponding to No. 4,	1.23
6. Drift soil, with clay subsoil, Oswego, N. Y., .....	.35 to 1.87
7. Alluvial bottom soil, Louisiana, .....	.41 to 2.08
8. Barren, pine-hill land, Louisiana, .....	.09
9. Sandy soil, Rio Grande, N. J., .....	.225 to .505
10. Soils from Kansas and Nebraska, prairie, .....	.45 to .75
11. Sugar-cane soil, Demerara, cropped 15 years, .....	.08
12. Sugar-cane soil, Jamaica, .....	.39
13. Rhine alluvium, Zuider Zee, Holland, highly fertile,	Surface,.... 4.69 15 in. deep, 5.10 30 in. deep, 2.48
14. Fertile wheat soil, Mid Lothian, Scotland,	1.23
15. Sterile soil, Upper Palatinate, Bavaria, .....	.10
16. Ten sandy soils, from Alabama, Florida and Georgia, .....	.045 to .141
17. Ten clay soils from Alabama, Georgia, South Carolina, Mississippi, Tennessee and Louisiana, .....	.065 to 3.054
18. Average of 466 non-calcareous soils of humid region of the U. S. (S. C., N. C., Ark., Ky. and Gulf States), .....	.11
19. Average of 313 soils of arid region of the U. S. (Cal., Wash., Montana),	1.36
20. Alkali soils of California, Washington and Montana, .....	.08 to 4.50
21. Black tschernosem, Poltava, Russia (wheat soil),	1.21
22. Volcanic soil, gray, Sumatra (tobacco soil), .....	.77
23. Granitic soil, Granville, N. C. (yellow, tobacco soil), .....	.07
24. Limestone soil, Donegal, Pa., .....	.61
25. Limestone soil, Rocky Spring, Pa., surface, .....	.41
Limestone soil, Rocky Spring, Pa., subsoil, .....	.25

Note.—These analyses are quoted from the following sources: Nos. 1-3, Richards, Bulletin No. 9, Chemical Division, U. S. Dept. of Agriculture; Nos. 9-13, Richardson, Special Report on the Investigation of Sorghum, 1892 (U. S. Dept. Agr.), pp. 53-64; Nos. 10-15, Johnson, How Crops Feed, pp. 362 and 396; Nos. 16-17, Hilgard, quoted by King, The Soil, pp. 84-87; Nos. 18-20, Hilgard, Bull. 3, U. S. Weather Bureau; Nos. 21-25, Frear, Rep. Pa. Ag. Exp. Station, 1894.

It is clear from these analyses that fertile soils usually contain 0.2 per cent. or upward of lime and that soils containing as little as 0.1 per cent. are usually marked for their barrenness. The texture

of the soil, since it affects the ease of extension of the plant roots, has some determining power over production; a loamy soil, through which roots readily distribute may be fairly productive with a low lime content that would cause sterility in a compact clay. On the other hand, since rain passes more readily by percolation through the former soil, it is more easily reduced by drainage to the lower limit of productiveness where the location of the soil favors leaching; sands are usually much less rich in lime than clays are.

The above illustrations do not exhibit the greatest extremes of lime percentage in soils; sea dunes often show a lower percentage, while coral sands, chalky and marly soils exhibit much higher ones; the writer has analyzed a soil from Juniata county, in this State, that contained upwards of 90 per cent. of calcium carbonate.

LIMESTONE SOILS NOT ALWAYS RICH IN LIME.

It is a common inference that soils derived from limestone formations are necessarily rich in lime; but this is very often not the case, owing to the relative ease with which calcium carbonate dissolves in the carbonated waters of the air. Merrill* remarks that thousands of feet of such strata may disappear without leaving more than a very thin coating of soil in their place. Penrose,† from the examination of an impure limestone and its residual clay, found that the latter represented only 2.365 per cent. of the former and that, of the lime, 98.93 per cent. was lost, the rock containing 44.79 per cent., the clay 3.91 per cent. Bernard‡ cites two soils which their owners thought to be rich in lime because derived from limestone rocks, viz: From the Forest marble strata, 92.60 per cent. calcium carbonate, soil, 3.28 per cent.; Cornbrash strata, rock, 91.30 per cent., soil 0.40 per cent. Possibly the most striking illustration of this sort is that given by Spencer,§ who finds in a sandy soil on the slopes of the Alleghenies 0.14 per cent. of lime, whereas the parent limestone contains over 30 per cent.

LIME IN COARSE AND FINE SOILS.

Some facts concerning the condition of the lime in different soils may be noted. Bernard,|| from the examination of over one hundred soils of Jurassic origin from the district of Saone-et-Loire, France, finds equal percentages of lime in the several portions as to fineness, into which each soil was divided by sifting. In these soils, the lime is supposed to have been deposited with organic remains. But in certain soils from Cretaceous formations the percentage of lime is

*Rocks, etc., pp. 221-2.

†Annual Report Geol. Survey, Arkansas, 1890, p. 179.

‡Le Calcaire, pp. 120-126.

§Report of the Geological Survey of Georgia.

|| Le Calcaire, pp. 44-53.

much larger in the finer than in the coarser portions of the soil; Bernard believes this difference is due to a chemical precipitation of the lime in the latter soils.

LIME IN SURFACE AND SUBSOILS.

Despite the influence of cropping and leaching, the surface soil usually contains more lime than the corresponding sub-soil. King,* taking the averages of a number of analyses of sand and clay soils finds in the sand: Surface, .115 per cent.; sub-soil, 0.096 per cent.; clay, surface, 1,761 per cent.; sub-soil, 1,481 per cent. This is doubtless due to the abundance of lime dissolved in the soil water and brought by the wick-like action of the soil to the surface, where it is left upon the evaporation of the moisture. The effect of such upward translocation is distinctly seen in comparing the soils of the humid and the arid regions, the upward movement of soluble matters being uncompensated in the latter climate by the leaching effect of rains. To the resulting abundance of lime in these soils, upland and lowland, Hilgard attributes their high and very uniform productiveness when they are irrigated.

SOLUBILITY OF LIME.

The condition of ready solubility of lime in the soil is indicated by the fact that on examination of the results of aqueous extraction of seventeen soils discussed by Johnson,† lime was found to make up from 6 to 25 per cent. of the solid extract, being the most abundantly extracted base, constituting 20 per cent. or more of the solid extract in seven out of the seventeen cases. This is further shown by the analyses of drainage waters by Way‡ and of lysimeter waters by Zöller,§ the extracts in the former containing 10 to 25 per cent. of lime, and those of the latter 22 to 32 per cent. Magnesia was much less abundantly dissolved, and, usually, potash was more abundant when the percentage of lime was high. Moreover, Ulbricht,|| in examining the solubility of the several constituents of various soils upon repeated extraction with water, has shown that lime, more than any other constituent, maintains its readiness of solution.

The lime which is removed from the soil by water is chiefly in combination as the carbonate, sulfate, nitrate, chlorid or phosphate. Very dilute acids remove it in scarcely greater quantities than are represented by its compounds, in the soil, with the above-named acids. Much larger quantities are extractible by the use of moderately strong acids; in such cases, considerable quantities of soluble

*The Soil, p. 85.

†How Crops Feed, pp. 310-312.

‡Jour. Roy. Agri. Soc., 17, 123; quoted by Johnson, Op. cit.; p. 313.

§Quoted by Johnson, Op. cit., p. 315.

||Versuchs-Stat., 5, 207.

silica and alumina are also liberated. It is inferred that the lime was present in combination with the silica and alumina, probably in the hydrous silicates known to mineralogists as the zeolites, which are readily decomposed by moderately strong acids with the production of soluble silica. Thus, Hilgard* notes that in the prairie soils of Alabama, Mississippi and Texas, a large percentage of lime is accompanied by high percentages of soluble silica and alumina. In some cases 1 or even 2 per cent. of lime is present, and in the mulatto clay lands of Tennessee, 6.5 to 8.4 per cent., and scarcely a trace of carbonic acid is found; in these cases, the lime is probably present as a zeolitic silicate.

RELATION TO ORGANIC MATTER.

The relation of the lime in soils to the organic matter is one of extreme variability. In the soils analyzed by Richards (see preceding table), the proportion of lime to organic matter varied from 1:1.5, in a light, fertile basaltic soil from the State of Washington, to 1:37 in a cultivated peat from Berrien county, Mich. Infertility not infrequently occurs where the ratio of organic matter is 20 or higher. Tacket† bases his classification of moor soils upon their lime content, the characters and treatments corresponding. His classes are: (1) upland moor, 0.5 per cent. lime; (2) intermediate moor, 0.5 to 2.5 per cent. lime; (3) lower, or meadow, moor, over 2.5 per cent. lime. It is notable that despite the facts that the acids of the humus, such as the humic, ulmic, apocrenic and crenic, have the power to decompose calcium carbonate with the formation of calcium humates, ulmates, apocrenates and crenates, and that the first three of these classes of compounds are very difficultly soluble in water, the tendency of upland soils rich in organic matter is to be deficient in lime, while those of the lowlands are better and often richly supplied.

VEGETATION TYPICAL OF NATURE OF SOIL.

As was noted in an earlier paragraph, the character of the soil, and especially its richness in lime, is often indicated by the nature of the vegetation growing upon it when in its virgin state. Thus, Hilgard‡ notes that on the long-leaf pine bottom and hummock lands of Mississippi, with 0.05 to 0.4 per cent. of lime, where water stands in the undrained sub-soil, the ink or gall-berry, wax-myrtle and similar plants prevail, but disappear as the calcareous regions on each side are approached.

Heinrich§ states that lime is certainly not lacking when the hedge-vetch, birds'-tare, chickling-vetch and red or other clovers form the natural vegetation, or when the oak, birch and locust flourish nearby, but that a deficiency of lime is to be suspected when there is a large

*X Census of the United States, 5, 81.

†Chem. Zeitung, 1895, No. 95.

‡X Census, 5, 267.

§Mergel u. Mergeln, 20-21.

quantity of sorrel (*Rumex acetellose*) or *Chrysanthemum segatum*, though no importance is to be attached to the presence of single individuals of these species for the reason that sorrel has been observed growing in marl pits, and in culture pots whose soil contained as much as 1 per cent. of lime. This author states that but few plants are really injuriously affected by lime and says that Uffelmann's supposition* that hearts-ease, quick-grass and chamomile disappear after a liming, is not credible.

A. Bernard† mentions the sand or maritime pine, the chlorotic varieties of the grape, the broom, digitalis and the chestnut as plants preferring non-calcareous soil. Speaking of the latter in particular, he urges that where the chestnut flourishes, the soil will be found poor in lime, even though the geological formation from which it is derived ordinarily yields a calcareous soil. Thus, examining the soil alone, the roots of a chestnut growing in a calcareous woodland of Ardèche, France, he found from traces up to only 0.6 per cent. of lime.

The laurel and the winter-green may be also mentioned as plants preferring non-calcareous soils.

Wheeler, Hartwell and Tucker‡ mention, as characteristic of the vegetation of certain acid upland soils of Rhode Island, birds-foot violet (*Viola pedata*, L.), wild or beard grass (*Andropogon scoparius*, Mx.), species of St. John's wort (*Hypericum*), common or soft rush (*Juncus effusus*, L.), wood rush (*Luzula campestris*, D. C.), and several mosses; while common sorrel (*Rumex acetellosa*, L.), appears as soon as cultivation is begun.

EFFECTIVE AMOUNT OF LIME IN SOIL.

The quantities of acid-soluble lime in the soil that are requisite to bring about the above noted differences in the kind and manner of growth of plants must vary both with the texture of the soil, as noted earlier, and with the quantities of acid-forming mineral and organic substances that are present. It is not, therefore, surprising that various investigators differ in opinions derived from observations upon different sets of soils. Thus Lloyd,§ states that, with rare exceptions, soils containing 2 per cent. of lime will not require liming; that soils containing 0.5 to 2 per cent. are usually benefitted by liming, and that it is indispensable to the profitable farming of soils containing less than 0.5 per cent. of lime.

Hilgard|| says that to manifest itself unequivocally in the tree growth, lime should not fall much below 0.1 per cent. in the lightest

*Mergel u. Meigeln, 1893, 23.

†Le Calcaire, 208.

‡Report R. I. Agr. Exp. Station, 1895, 240.

§Science of Agriculture, 1894, 111.

||Op. cit., p. 76.

sandy soil, 0.25 in clay loams, or 0.5 in heavy clays, and may advantageously rise to 1 or even 2 per cent.; beyond this, it does not affect the soil favorably except in its physical characters. This writer* has observed that on sandy lands containing 0.04 to 0.13 per cent. of lime, having a depth of eight inches of surface soil, the long-leaf pine which grows naturally upon it is, upon the application of lime, supplanted by a growth of oaks.

R. Heinrich† claims that a good soil should contain at least 0.2 to 0.3 per cent. of lime and that liming is certainly required when the proportion falls to 0.1 per cent., and, in case of a heavy soil, it is needful before the amount has been reduced to 0.1 per cent.; when 0.15 per cent. is present, liming does not lead to an increased growth of rye, oats or potatoes, and when 0.3 per cent. is present, liming or marling is without beneficial result. The same investigator, in an earlier portion of his memoir, relates the result of experiments in the culture of various plants in soils to which different proportions of lime have been added; he concludes that:

	Lime (CaO) in soil. (Per cent.)
Lupine grow well with,	0.03 to 0.05
Potatoes and rye yield good crops, under good tillage, with as little as,	0.05
Peas and vetches die with less than,	0.10
but do quite well with this proportion.	
Red clover grows quite well with,	0.1 to 0.12
but dies with less than 0.1 per cent. and does best with 0.2 or more.	

LOSS OF LIME BY CROPPING.

A number of calculations have been made to show the outgo of lime in farm products. Thus King,‡ assuming a three-course rotation of corn, clover and oats to be followed for one hundred years, each with a total product of two tons per acre per annum, the hay and straw being returned to the soil, but the grain, or its equivalent being sold, finds that the hay and straw would contain 3,102 lbs. of lime, and the grain only 86 lbs., so that with an average of 1.88 tons of lime in the surface foot of soil, this alone would supply the needed lime for over 4,000 years, were there no other loss, without the aid of the lime present in the subsoil, which is more or less drawn upon by the roots of the crops.

Or, assuming a four-course rotation of corn, oats, wheat and mixed clover and timothy, producing average crops of the quantities mentioned in an earlier table (pages 54-55), assuming that all the wheat, half the oats, one-third of the corn and one-fourth of the

*Id. p. 204.

†Mergel u. Mergeln, p. 20.

‡The Soil, 102-104.

hay were sold, the remainder of the crops being fed upon the farm; that one cow were kept for each two acres under cultivation, yielding 7,000 lbs. of milk sold off the farm each year and that for each cow there were bought 750 lbs. of cotton-seed meal and 1,500 lbs. of bran each year, the outgo would be, for each acre:

	Lime (Lbs.)
In wheat ($6\frac{1}{4}$ bushels),	0.22
In oats ($6\frac{1}{4}$ bushels),	0.20
In corn (4 1-6 bushels),	0.07
In hay (220 lbs.),	2.98
In milk (3,500 lbs., at 2 lbs. of lime per 1,000 lbs. milk),	7.00
	<hr/> 10.47
The income would be:	
In 375 lbs. cotton-seed meal,	0.68
In 750 lbs. wheat bran,	1.27
	<hr/> 2.95
Net annual outgo by cropping,	<hr/> <hr/> 7.52

LIME ADDED IN FERTILIZERS.

On the other hand, the manurial substances brought upon the farm for the purpose of supplying nitrogen, phosphoric acid, potash and other substances commonly contain also considerable quantities of lime.

Thus, in a ton of the following substances lime is contained in the quantities and states of combination indicated:

TABLE V—Amounts of Lime in Various Fertilizers.

Substance.	Lime compound.	Pounds of lime.
Ashes (lime kiln),	Caustic lime and carbonate,	970
Ashes, wood, leached,	Carbonate and phosphate,	560
Ashes, wood, unleached,	Carbonate and phosphate,	620
Bone ash,	Phosphate,	360
Bone meal,	Phosphate,	540
Cottonseed hull ashes,	Carbonate and phosphate,	190
Gas lime,	Carbonate and sulfate,	350
Kainit,	Chlorid and sulfate,	23
Kieserit,	Chlorid and sulfate,	56
Marls,	Carbonate and phosphate,	0-900
Land plaster, Cayuga,	Sulfate and carbonate,	800-850
Land plaster, Nova Scotia,	Sulfate and carbonate,	530
South Carolina rock, ground,	Phosphate and carbonate,	540
South Carolina rock, dissolved,	Phosphate and sulfate,	420 (about)
Tannery ashes,	Carbonate and phosphate,	680
Tobacco stalks,	Nitrate, malate, etc.,	44
Tobacco stems,	Nitrate, malate, etc.,	54
Thomas slag phosphate,	Phosphate and oxid,	970

With every pound of phosphoric acid applied in the ordinary forms of commercial fertilizer, the presence of at least $1\frac{1}{4}$ lbs. of lime is assured.

From these facts it is clear that in an application of 200 lbs. of dissolved South Carolina rock, fully 40 lbs. of lime is added to the soil, an amount several times greater than that removed in a single year by the crops sold off from the acre.

INFLUENCES OF LIMING UPON SOILS AND THE VALUE OF MAGNESIAN LIMES

Having noted the quantities and conditions in which lime occurs naturally in the soil, and the ways in which it is lost or increased by the processes of cropping and chemical manuring, it remains to consider the changes wrought in the soil by the application of lime.

CLASSES OF EFFECTS OF LIMING.

Numerous observations and investigations have shown that the direct and indirect results of liming are quite numerous and complex, instead of being few and simple. The various results may, however, be grouped as those which affect:

- A. The mechanical condition of the soil;
- B. Its chemical composition particularly as regards
 - 1. The kind and proportion of available plant food it contains.
 - 2. The presence of substances injurious to plant life.
- C. The biological characters of the soil; i. e., the nature and vigor of the organisms living in it and of the plants growing upon it.

These different effects of liming will be discussed in the following paragraphs, free use being made of the numerous observations and experiments made elsewhere upon the subject; but the effects of lime upon a number of Pennsylvania soils that have shown in practice very marked benefits from liming, will be presented so far as they are indicated by the results of careful laboratory investigations made by the writer, with the aid of his assistants in the Chemical Laboratory of The Pennsylvania State College Experiment Station.

SUPPOSED INJURIOUS EFFECTS FROM MAGNESIAN LIMES.

It was thought desirable to study, at the same time, the effect of caustic magnesia upon these soils, for the reasons that a very large proportion of Pennsylvania limes are magnesian and that the general opinion of agricultural writers has been that highly magnesian limes may not only be of little use, but may even prove positively injurious

to the crops. Thus, Lloyd* states that lime is the only material of value in burnt lime and applies the adjective "bad" to a lime containing 60 per cent. of lime and 30 per cent. of magnesia. Low† says of the magnesian limestone of England: "If applied, after being calcined, in the same quantity as other limes, it produces a temporary sterility, burning, as it were, the soil; hence, it is termed hot lime and is applied in much smaller quantity than other kinds of lime." This action he attributes, after Sir Humphrey Davy, to the longer period of causticity commonly supposed to occur with magnesia. In the form of carbonate, he says, "magnesia seems to exercise a highly favorable action; and magnesian limestone may perhaps be regarded as the most valuable of any, since a smaller quantity of it suffices for the ends proposed. No other limestone is so efficient in the case of peaty soils, and it is probable that the superiority observed in the case of the limestone of the coal formation over that of the pure chalk is due to the presence of this earth."

Prof. Geo. H. Cook,‡ late geologist of the State of New Jersey, and Director of the New Jersey Experiment Stations, says, in speaking of limes: "It is doubtful whether magnesia has any fertilizing properties, and it is thought by many that it is a loss to buy and handle magnesian limes."

P. P. Dehérain,§ speaking of hydraulic limes in general rather than of magnesian limes simply, says they will, if spread upon the soil without previous complete exposure to the air, form a hard layer upon the soil during the first rain and become injurious rather than useful.

J. Boehm's|| observation that carbonate of magnesia is unable to take the place of lime in promoting healthy germination but is, instead, positively poisonous, has already been noted.

R. Heinrich,** having observed injury resulting from the effect of calcium carbonate upon the growth of the lupin, states that magnesium carbonate is far more injurious, the presence of 0.5 being sufficient to entirely prevent the growth of the plant. The same writer†† says: "It is suspected that applied in considerable quantity, so that, especially, the magnesia exceeds the amount of lime in the soil, it is as deadly to some plants as lime carbonate is to lupins. Different plants show different sensitiveness to the magnesia content of the soil. Most dolomitic rocks contain far more lime than magnesia; no immediate injury, therefore, results from their use, but because lime is more freely dissolved out of the surface soil than magnesia is, the injurious effect may be seen later when the magnesia

*Science of Agriculture, 113.

†Practical Agriculture (4th ed., 1845), 88.

‡N. J. Agr. Exp. Station, 2d Ann Rep., 31.

§Chimie agricole, 530.

||Ann. agronomiques, 1, 470.

**Mergel u Mergeln, 63.

††Ib. p. 31.

comes to be in excess. The injury from caustic magnesia is clearly established, but further investigation is needed regarding the effect of the carbonate."

The subject is quite fully discussed by Storer,* who notes that it was early observed by English chemists that certain limestones which had sometimes been found in practice to injure crops, contained magnesia, and that Tennant, on applying calcined magnesia to various soils with different crops, found that his plants either died, were unhealthy or vegetated very imperfectly; also, that Knop found, in growing plants by water culture (i. e., in very dilute solutions of plant foods), that magnesium salts are distinctly harmful unless accompanied by abundance of lime, potash or ammonia salts; by themselves, the magnesium salts caused peculiar malformations of the plant roots, followed shortly by the death of the plants.

Storer notes, on the other hand, that Sir Humphry Davy found that the very magnesian limestones to which objection was made, gave very beneficial results on certain soils and that magnesia, though injurious when present in caustic condition in considerable quantity in ordinary soils, may be beneficial when mixed with peat or when present as carbonate. He also notes Stöckhardt found, in the limestones producing the best results and most enduring upon the lowlands of Saxony, as much as 40 per cent. of magnesia. The suggestion is made that the readier solubility of magnesium carbonate in the carbonated soil-water may give magnesian limes real superiority over pure limes as ameliorants of heavy land.

Viala and Ravaz† have observed that dolomitic soils are not nearly as injurious in the production of chlorosis of the vine as are more purely calcareous lands. Bernard suggests that this is due to the somewhat greater resistance to decomposition offered by magnesium carbonate.

O. Kellner‡ urges that Magnesia is useful and poisoning of the plant by it is the result simply of using it in too large quantities.

FUNCTIONS OF MAGNESIUM IN PLANTS.

In support of this opinion it may be summarily noted in this connection, as established by numerous experiments by the methods of water-culture and of sand-culture, that magnesium is absolutely indispensable to the growth of plants to full maturity. While all its functions in the plant are not known, it is certainly able to neutralize acids as lime does, though it does not form crystallizable compounds so easily thrown out of circulation as calcium carbonate or calcium oxalate. Like lime, it is present in aleurone grains with albuminoid

*Agriculture, 4th ed., 1897, II, 125-7.

†Bernard, *Le Calcaire*, 62.

‡American Fertilizer, 6, 245.

materials and forms alkaline phosphates which may aid in the movement of albuminoids from one part of the plant to another. Its most clearly established function, however, is its necessary connection with the formation of chlorophyll, the green coloring matter through whose agency, under the action of sunlight, the plant is enable to fix the carbonic acid of the air in its leaves in the form of sugar, starch or oil. Von Raumer* found that in the scarlet runner, when deprived of magnesium, the uppermost joints soon ceased to lengthen, became exceptionally thick and hard and showed only the faintest green tint, the color being almost white. Hoppe-Seyler† found in the pure crystallized chlorophyllan obtained from grass, 0.34 per cent. of magnesia; and chlorophyllan appears to be closely related to the ordinary chlorophyll.

USE OF MAGNESIUM SULFATE AS A FERTILIZER.

A second fact in support of this opinion is the good result occasionally attending the use as a fertilizer of magnesium sulfate (Epsom salts) in the form of the Stassfurt salts, kieserit and krugit.

PENNSYLVANIA EXPERIMENTS.

SOILS EXPERIMENTED UPON.

The soils used in the experiments hereafter described were carefully selected to represent a large variety of the soils for which a large return from liming was claimed by various correspondents. The source, nature, response to liming and method of sampling of the several soils are stated below.

I. *Ironstone soil*, from the Spring-and-Meadow Farm, Washington Township, York County, sampled by Mr. L. W. Lighty, East Berlin, Adams County, Pa. This soil formation lies between strips of blue shale, outside of which are found red shale and red sandstone; the ironstone soil is about three-fourths of a mile wide and extends from the Susquehanna opposite Marietta, bearing south of west, passing south of Gettysburg. The soil is uneven in formation; 10 per cent. of it is a whitish clay of very fine texture, runny when wet, but powdery, not cloddy, when dry; 5 per cent. is a tough, heavy, cold clay, mixed with a small proportion of coarse sand; this soil dries very slowly and bakes to clods; 5 per cent. is pure, rather coarse sand mixed with flint and granite, but 80 per cent. is a very fine sand, mixed with less clay, and it becomes sticky and smeary when wet and dries slowly; when handled properly in a dry condition, it works very nicely; washes and gullies when on an exposed slope. In general, the soil is a fine, grayish-yellow sand. It is very deep, sometimes as much as

*Versuchs-Stationen, 20, 263-272.

†Quoted by Johnson, How Crops Grow (1890), 126.

forty feet. Soil taken from far below the surface and spread upon the ground, supports at once a very rank, vigorous vegetation, and is rarely bare, weeds and briars growing rapidly in the absence of crops. The soil bears drought very well, and is a hard, rough soil, but responds well to treatment. All crops and trees grow well upon it.

The sample was taken from a tract of four acres, having a surface soil one foot deep, with a sub-soil similar, but sharper and full of boulders. The tract was rolling upland, rather damp, had been long under cultivation in a rotation of corn, wheat and clover; its production is about 15 bushels of wheat and 60 bushels of ear corn; its plow depth is about 10 inches. Liming alone is not so noticeably useful as its application in connection with clover sod or manure. The soil is naturally well supplied with humus and rarely becomes deficient therein. When lime is applied to this soil, 20 to 50 bushels makes no easily apparent change in its condition; if more than 50 bushels be added, the soil becomes mortar-like and hard to handle. After liming, the retentiveness for moisture appears to be increased. The particular tract sampled had not been limed for at least forty years, and was in corn-stubble when the sample was taken; sub-samples were taken of the surface soil at twelve different points, carefully mixed by shoveling over and passed through a one-half inch screen; 3 per cent., consisting of roots and small stones, failed to pass the screen. The combined samples amounted to several barrel-fuls.

II. *Black slate soil*, from Hopewell Township, Cumberland County, Pa., about five miles north of Shippensburg; sampled by Hon. S. M. Wherry, of Shippensburg. This soil is light, easily tilled, easily affected by drought, but yielding well in wet seasons; liable to wash. The soil grows hickory, all kinds of oaks, some pines, fall-grass, rag-weed and all forms of briars, and is especially good for wheat. The surface soil is about twelve inches deep, although the plow-depth is commonly only six to eight inches. The sub-soil is hard, black slate or red shale. Lime seems more beneficial upon this than upon most soils in the locality. The tract of ten acres from which the sample was taken had never been limed, but was an old soil under a rotation of corn, oats, wheat and grass. Sub-samples were taken from eight points in the tract, to a total weight of 1,000 to 1,200 pounds; after careful mixing the soil was screened and about one-half of the entire amount—composed of sod, roots and large pieces of slate—failed to pass a half-inch mesh screen.

III. *Red shale* from Lykens Valley, Dauphin County, Pa., sampled by Mr. John Moyer, Gratz, Pa. This soil is a dry, sloping upland, with surface soil of fourteen to twenty inches, and a plow-depth of six or seven inches, and with a red gravel sub-soil. The soil tends to bake and solidify on drying so as to greatly injure any crop growing upon the land. The golden rod and plantain are the most conspicu-

ous weeds, and wheat grows better than other crops, but the soil is not naturally strong; the fertility after the use of lime, with manure, is greatly improved, and the soil is kept much lighter and more porous. The twenty-acre tract from which the sample was taken had not been limed for at least twenty years, and, before that, only infrequently and at a rate of not more than fifty bushels per acre. The land had been under cultivation for a long time, and when sampled was in corn; ten sub-samples were taken at different points to a total amount of four bushels; these were well mixed and put through a one-fourth inch screen; stones and roots to the amount of one-fourth of the original soil were separated.

IV. Limestone clay from the eastern slope of the limestone strata running through Morrison's Cove, in South Waverly Township, Bedford County, one mile from Loysburg Gap; sampled by Mr. J. S. Biddle, of Loysburg, Pa. The soil is a very heavy "limestone" clay, which cannot be worked wet and bakes on drying. Rag-weed, the wild cherry and apple and clover grow vigorously and corn does very well. The soil is about six to eight inches deep, and the sub-soil is heavy clay several feet deep. Lime loosens it. The tract of two acres from which the sample was taken was dry, sloping upland that had been under cultivation for over fifty years and had never been limed; sub-samples were taken at twelve places and the mixed soil passed through a one-quarter inch screen, through which one-third of the weight refused to pass, composed of stone, roots, etc.

V. Glacial loam from Scrubgrass Township, Venango County, sampled by Mr. Ed. Anderson, of Big Bend, Pa. This soil is loose, with a gravelly sub-soil, containing a little clay; wet weather does not injuriously affect it. The prevailing forest growth is chestnut, and produces about fifteen bushels of wheat to the acre. The sample was taken from an upland tract of twenty-five acres, part upland level, part slope; sub-samples were taken at six points to a total weight of 1,000 pounds. Of this, one-third, composed of small stone, grass roots, etc., failed to pass a one-quarter inch screen. This land had been in wheat four years before and in grass since then; the soil was old and had never been limed.

VI. Muck soil from the "sand barrens" of Centre County, a narrow strip one-half to several miles in width, extending for twenty-five to thirty miles through Nittany Valley, and containing many small hollows, more or less filled with muck and sandy wash. The sample was taken at a spot about two and one-half miles from the State College, by Mr. W. S. Sweetser, Assistant Chemist of the Experiment Station; the hollow from which it was taken was 150 to 200 square feet in area, with a surface of much five to six inches deep, and with a sub-soil of almost pure sand. The vegetation upon the surrounding tract was of pine, chestnut and oak. The soil was virgin, of course, and ten samples, amounting to about a barrel, were taken. Of this,

one-tenth only was too coarse to pass a one-quarter inch mesh, the coarse material being composed solely of sticks and roots.

VII. *Limestone clay* soil from Nittany Valley, Centre County, on the farm of Mr. A. Markle, State College, Pa., representing well the large soil areas forming the floor of central Pennsylvania valleys, the soil being formed from the Lower Silurian rocks. This soil often responds very well to liming, the texture being made more porous, and crop yields considerably higher. The characteristic tree is the oak, and rag-weed the most abundant mid-summer weed. The sample was taken by Mr. W. S. Sweetser, from a field of one acre area that had never been limed; it was in corn at the time, forming part of the ordinary four-course rotation. The situation was upland, the soil well drained naturally, with surface soil of ten inches depth, and a usual plow-depth of seven to eight inches. The sub-samples were taken from eleven points to the amount of a barrel. Of this, 4 per cent. only, composed of small stones with a few roots, was too coarse to pass a one-quarter inch mesh.

VIII. From the farm of Mr. Mitchell Bachle, Blanchard, Pa., *Creek bottom loam*, sampled by Mr. C. W. Norris, Assistant Chemist of the Experiment Station. Soil was of rather light, sandy texture, and of light color; the surface of the ground sloped a little toward the south-east, but was otherwise quite level. The land was cropped with clover, had been long cultivated and never limed, nor has it been manured for seven or eight years. The plow depth is 10 inches. Land responds well to liming. The tract sampled lay near the creek, was of two acres area, and was sampled in 10 places. Of the combined sub-samples, little more than 2 per cent., consisting of small stones and roots, failed to pass a screen of one-quarter inch mesh.

IX. *Red shale* soil from the farm of Mr. David Mapes, about two miles west of Beech Creek, Clinton County. The soil is especially productive of clover and the plaintain was the most conspicuous weed upon the tract sampled. The effect of liming is to loosen the soil and greatly improve the yield. The tract was sloping upland, dry, with a surface soil ten inches deep, and a hard red-shale sub-soil; the plow-depth was eight inches. The field had been in cultivation for twenty years in the ordinary four-course rotation and is not known to have been limed. Over an area of two to three acres, sub-samples were taken at thirteen places to the amount of 700 pounds. Of this, 27 per cent., composed of small, flat stones, failed to pass a one-quarter inch mesh.

CHEMICAL ANALYSIS.

Of each of the samples thus collected, a large portion was carefully air-dried in a drying-closet, the sample allowed to remain exposed for some time to the air of the laboratory and then carefully sifted through a one-half millimeter seive to remove gravel, roots, etc. Of

these various samples the following proportions were able to pass the seive, the figures for Samples VI and VII having failed to be preserved:

	Per cent.
I,	78.4
II,	50.0
III,	75.1
IV,	77.1
V,	88.6
VIII,	89.7
IX,	79.1

In preparing a solution of these soils for the purpose of determining in part the materials capable of solution in hydrochloric acid of 1.115 specific gravity—the solvent customarily employed in soil analyses and supposed to indicate the kind and amount of material capable of being taken up by plants sooner or later as the land is cropped—the following method was used: Ten grammes of the air-dry soil were introduced into a small flask, 100 c. c. of the acid added, the flask connected with a reflux condenser and digested for ten hours on a water-bath at the temperature of boiling water. The flask was cooled, the liquid filtered off from the undissolved residue, the filtrate evaporated to dryness. The soluble silica present in the original acid solution having been thus rendered insoluble, the other substances were redissolved in a few drops of hydrochloric acid and hot water and the solution filtered. The filtrate was made up to 500 c. c., and various portions of it used for determining several of the soil constituents by the official methods of the Association of Official Agricultural Chemists of the United States.

LIME AND MAGNESIUM CARBONATES IN THE SOILS.

In the following table are given the percentages of hygroscopic moisture, lime, magnesia and carbonic acid present in the several soils; also, the proportions of the lime present in the form of carbonate; these determinations were made by Mr. C. W. Norris, Assistant Chemist; in no case was the carbonic acid liberated on warming the soil with dilute acid, sufficient to combine with all the lime present, much less with the magnesia also.

TABLE VI—Lime, Magnesia and Carbonic Acid in Soils. (Per Cent.)

Soil.	Hygroscopic moisture.	Lime.	Magnesia.	Carbonic acid.	Proportion of lime combined as carbonate.
I.	2.37	0.83	0.75	0.084	5.1
II.	2.00	0.24	0.71	0.039	20.4
III.	1.39	0.35	0.43	0.035	17.6
IV.	1.64	0.29	0.44	0.044	19.6
V.	1.98	0.08	0.19	0.005	23.8
VI.	4.85	0.11	0.19	0.046	53.6
VII.	1.36	0.26	0.35	0.039	15.2
VIII.	1.49	0.29	0.45	0.030	13.3
IX.	1.78	0.28	0.69	0.048	21.8

The variations in hygroscopic moisture are evidently too slight to introduce any material error in conclusions drawn from a direct comparison of the foregoing figures.

It is interesting to observe that only in the case of the glacial loam, No. V, and of the muck soil, No. VI, are the proportions of lime less than 0.2 per cent., the amount considered sufficient for the food supply of agricultural plants. Yet, except in case of the ironstone soil, the proportions are not far above this requisite proportion.

In every instance except those of No. I and No. VI, the ironstone and muck soils respectively, the percentage of magnesia in the soil is appreciably greater than that of lime; and in the exceptional soils indicated the lime is barely more than equal to the magnesia.

Except in the muck soil, only a small part of the alkaline earths are present as carbonates;* in most instances, not more than 20 per cent. of the lime is so combined, and in the ironstone soil only 5 per cent. Doubtless a very considerable part of that dissolved is present in the soils in the form of silicates.

RATIO OF LIME TO MAGNESIA.

Concerning the proportions which the magnesia bears to the lime in these soils, it may be further remarked that the excess of magnesia here observed is not at all unusual; the mean percentage of lime in 466 non-calcareous soils from humid regions that were analyzed by Hilgard, was 0.108 per cent., while that of magnesia was 0.225 per cent.; in 313 soils from arid regions, the average lime content was 1.362 per cent.; that of magnesia, 1.411 per cent.

*Much care was used in determining the carbonic acid: 20 grammes of the fine, air-dry soil was introduced into a small flask, covered with freshly boiled water and thoroughly moistened by agitation. The flask was then connected with such absorption apparatus that the air entering the flask is free from carbonic acid, while any of this gas liberated from the soil is absorbed, after the air has been dried, in a special weighed portion of the apparatus, from whose increased weight the quantity of carbonic acid is ascertained. 40 c.c. of concentrated hydrochloric acid was then introduced into the flask, its contents heated to boiling and the air drawn through the apparatus for 15 minutes as the flask cooled.

In view of these facts, it is unsafe to conclude that an excess of magnesia soluble in hydrochloric acid of 1.115 specific gravity is indicative of a condition of the soil whereby pronounced injury must result to crops growing upon it. It is more probable that the supposed injurious action must be attributed to the presence in excess of some particular magnesian compound or compounds, rather than of magnesian compounds in general.

The mere fact that the composition of large agricultural areas represented by the above analyses shows an average preponderance of magnesia over lime, does not, of course, preclude the possibility that a reverse relation of the acid soluble portion of these two soil components might prove more advantageous to plants grown under the artificial conditions of agriculture. There is, however, no warrant in existing knowledge upon the subject for concluding that any part of the benefits observed to result from the application of lime to the several soils experimented upon, arises from a change in the ratio between the magnesia and lime present. It is noteworthy, however, that where the differences in percentage between the two are only slight, no unusual application of lime would be required to overcome it; thus, for each 0.1 per cent. of excess of magnesia over lime, an application of little more than a ton of pure lime per acre would equalize the amounts of these substances in the surface soil taken to a depth of eight inches; whereas, applications of ten tons to the acre are not very infrequent.

Physical and Chemical Effects of Applications of Lime and Magnesia.

DETAILED PLAN OF EXPERIMENT.

Owing to the difficulty of detecting by analysis minor changes in the composition of soils, a maximum application was determined upon. Two hundred bushels of the heavier stone lime would weigh about 18,000 lbs.; assuming the dry surface soil to weigh 3,600,000 lbs. per acre, taken to the depth of a foot, such an application would correspond to 1 lb. of lime to each 200 lbs. of soil. As the mechanical mixture of the soil and lime is not perfect under the usual conditions of liming, it doubtless happens quite often that the immediate influence of the lime applied is limited to a zone of three or four inches depth. Under laboratory conditions, the admixture is much more perfect, so that the above proportion need not be considered as excessive in such degree as to impair the value of any results obtained.

Both the lime and magnesia were chemically pure, and perfectly caustic; only freshly ignited materials, cooled under conditions that precluded air-slaking, were used.

As it was considered probable that the chief effects would be those resulting from chemical reactions produced by the lime and magnesia respectively, the latter was not employed in quantity equal to the lime, but in such amount as would be chemically equivalent to it, viz: 40 parts of magnesia to 56 parts of lime.

The quantity of soil used was 2,000 grammes.

Three treatments were given to as many portions of the several soils.

A. Preservation in a moist condition without any admixture.

B. Mixture with 10 grammes of lime, and preservation in a moist condition.

C. Mixture with 7.14 grammes of magnesia, and preservation in a moist condition.

The lime and magnesia were thoroughly mixed with the soils, both being in dry condition.

The dry soils subjected to the several treatments were then introduced into large bottles, so covered as to protect their contents from the ready entrance of dust, insects, etc., but without preventing a constant change of the air in the bottles. The soils were then carefully moistened without stirring, placed in a basement room and kept there for ten months. During the first three months water was added in small quantities, to maintain a uniform condition of moistness so far as the eye could determine. At the close of the ten-month period, the soils were air-dried, again sifted through a one-half mm. seive, as at first, and preserved in sealed jars pending analysis.

MECHANICAL EFFECTS OF LIMING.

INFLUENCE UPON CLAY SOILS TO INCREASE POROSITY.

It is a matter of almost universal comment that the application of lime to a "runny" or heavy clay results in a marked increase in the porosity, lightness and crumbly character which are essential to a soil fit for the highest tillage. Indeed, so marked is the influence of lime upon such soils that, in some localities, it is asserted that only upon heavy clay land is lime ever beneficial. To reach an understanding of this effect of lime, it is needful to consider the essential differences between the heavy clay and the lighter soils. The terms "heavy" and "light," as used in this connection, do not refer to weight, because a cubic foot of dry sand weighs about 110 lbs., while a cubic foot of clay, taken from "heavy" land, often weighs only about 80 lbs. Reference is had instead to the draught required for their tillage, the adhesiveness and strong coherence of the clays, greatly increasing the power necessary to draw the plow through them as contrasted with sandy soils.

MECHANICAL CHARACTER OF CLAY SOILS.

These differences are due chiefly to the texture of the soil or, in other words, to its mechanical structure. All soils are composed of more or less finely sub-divided minerals resulting from the weathering of the rock from which the soils were derived, with more or less "humus," or decayed vegetable matter admixed. A separation of the fine and coarse particles in various soils shows them to be vastly different in the proportions of the particles of various diameters which they contain. The following data obtained by Whitney,* in examination of the coarse "pine barrens" and heavy Helderberg limestone clay soils of Maryland, will serve to illustrate the mechanical differences between the two types of soil (all material coarser than two mm. having been first removed by sifting):

	Pine barrens soil.	Helderberg limestone soil.
Number of grains per gramme of soil (millions),	1,682	19,628
Surface area of the particles in 1 gramme of soil (in centimeters),	496	4,576
Empty space in the dry soils (per cent.),	40	66
Water content when saturated (per cent.),	20.1	41.2

It is clear, therefore, that the number of grains in a given weight of clay soil is very much greater than in the same amount of a sandy soil, and, consequently, that the average diameters of the clay particles must be much less than those of the sand grains. It is further clear that, since the density of the minerals composing sand and clay are much the same, a dry clay soil weighing less than a sandy one, the arrangement of particles in the clay must be such as to leave more empty space, and direct examinations of the soils in the field show this to be true. A clay soil will, when saturated, hold more water than a sand. Owing to the fineness of pores in a clay soil, water will be lifted higher in it by capillary action, will be pulled out of or through it more slowly by the influence of gravity and, when the soil is dry, will distribute more slowly through it. It is, therefore, characteristic of clay soils to be more moist than sandy soils in damp weather, to dry more slowly in spring time, to swell on becoming moist after a dry season, to heave on freezing by expansion of the water contained and to bake into a hard mass on drying. In such compact soils, the roots of plants penetrate with difficulty, the roots

*U. S. Weather Bureau, Bull. 4.

are broken by the heaving during the winter's frost and plants suffer from excessive wetness and coolness of the soil in spring time and from excessive droughts in summer.

Furthermore, if such soils are trampled, pressed by the plow share or kneaded in any way, the arrangement of the particles is changed and the clay is said to be "puddled." In such condition water, even under high pressure, scarcely passes through it; upon drying, it bakes in the form of hard clods; it is readily gullied by running water, making the streams highly muddy. The tillage of such land requires the greatest care.

The plasticity that is characteristic of clay soils is by some attributed to a gummy, or "colloidal," cementing substance, probably a silicate of alumina; by others it is urged that the very fineness of the particles is in itself sufficient to account for this quality. There is some evidence that both are in part correct.

FLOCCULATION OF CLAYS.

When the extremely fine silt or mud from certain clays is suspended in rain water, it often settles out only very slowly. Prof. Wm. H. Brewer, of Yale University, in a private communication, informed the writer that a sample taken by him from the muddy waters of the Missouri river and placed on a shelf, where it was free from agitation, failed to settle clear even after six months had elapsed.

If, however, certain saline solutions are admixed with the muddy water, the precipitation of the silt is greatly hastened. This is accounted for upon the supposition that several of the fine particles are made under the influence of these solutions, to cohere, in light flocks, whereby their surface is diminished and they settle out from the liquid more readily. Thus, when the muddy waters of the Mississippi encounter the waters of the Gulf, the salts in the latter bring about the "flocculation," as this change in condition is termed, and the silt deposits to form the great delta which is ever pushing out into the Gulf.

On examining the flocculating power of various substances, Schlösing* found that quick-lime and the various salts of lime were the most active flocculants, magnesium salts nearly as effective, potassium salts weaker and the salts of sodium and ammonium still weaker. In some cases, two parts of lime in the form of chlorid, nitrate or sulfate, caused immediate flocculation in 10,000 parts of turbid, clayey liquid.

Hilgard has repeated Schlösing's experiments with like results.

The action of these flocculants upon a "runny" clay soil likewise results in its granulation or flocculation. If, however, the flocculant

*Cf. Storer, *Agriculture*, 4th ed., Vol. II, p. 144.

be removed by leaching, the "runny" character of the clay reappears. To show this action, Hilgard suggests the following experiment: Work a portion of tough clay into a plastic mass with soft water; on the one hand, mix one part of caustic lime with 200 of the clay before working into a paste with water; on drying the former portion becomes of almost stony hardness, the latter crumbles readily at the touch.

THEORIES OF FLOCCULATION.

The cause of this action is not fully understood. Schlösing found that in washing the soluble materials from soils by water, silt was held back when a current of carbonic acid gas was passed through the soil during the washing; from this fact it has been inferred that the acid carbonate of lime is the active flocculant. Hilgard* also observed that the destruction of the causticity of the lime in a magma of limed clay by causing a stream of carbonic acid to bubble through it for twenty-four hours, did not at all restore the plasticity of the clay; hence, the flocculation does not necessarily require caustic lime. But the action of the neutral carbonate is much weaker.

Hilgard, Brewer and Barus,† proceeding upon the theory that the clay particles are, in part at least, in a gummy or colloidal condition, suggest that flocculation results from a dehydration of the clay under the action of the saline solutions. Whitney urges, however, that such an assumption is needless since the facts may be accounted for by the laws of surface tension; for, assuming two grains of clay to lie in contact with each other on the surface of a liquid, if the attraction of the liquid for the surfaces of the clay is greater than the attraction between the different portions of the liquid, the latter will rise between the particles and tend to separate them; if, on the other hand, the reverse is true, the clay particles would, when separated, tend to come together. The determinations made by this investigator‡ of the power of various flocculant solutions, as compared with water, to rise in a glass tube, shows, however, that the former rise higher and that their observed relations in this respect do not correspond with their flocculant activities as ascertained by Schlösing and Hilgard.

The observations of King§ do not, however, fully accord with Whitney's in respect to the influence of lime upon the capillary movement of water; for he found that the rate at which water passed upward through columns of coarse sand and away by evaporation, was decreased rather than increased by the addition of lime water, thus indicating for the latter a lower capillary power.

*Storer. *Id.*, p. 146.

†O. Whitney, Bull. 4, U. S. Weather Bureau, p. 21.

‡*Id.* pp. 15 and 16.

§The Soil, pp. 177-8.

DURATION OF EFFECT.

Whatever be the explanation, the fact remains that the "lightening" effect upon such soils resulting from liming is very marked and often lasts for years.

INFLUENCE UPON WATER MOVEMENT.

Pearsen* has noted the interesting fact that a clay soil which allowed a layer of water only five centimeters (two inches) deep to penetrate through it in no less time than twenty-nine days and nineteen hours, when mixed with 2.5 per cent. of lime, permitted the completion of the percolation in only seven hours.

In case of such a soil lying upon a steep slope, it is readily seen that one result of liming would be the readier percolation of the water through the body of the soil with a correspondingly lessened tendency to form rivulets upon the surface, which might wash it into gullies; nor would the percolation be accompanied by the removal of the finer particles of the soil.

MODIFYING EFFECT OF THE LIME ALREADY IN THE SOILS.

Hollemann,† working upon stiff clays at Groningen, Holland, found their porosity improved by addition of lime in the form of carbonate, whenever the quantity of lime in the soil was less than 0.15 per cent.; but that no benefit was perceptible from its application when the soil contained as much as 0.5 per cent.

King‡ observes that there appear to be some exceptions to the general rule that the presence of calcium carbonate ensures the friability of fine clays, from the fact that there are many clays, very impervious to water, plastic and adhesive, which are unfitted for use in making brick or pottery, because of the lime they contain, the amount sometimes reaching 5 per cent. As a possible explanation, this writer suggests that it may be that the lime, once in the impervious clay, could not be acted upon by the carbonic acid sufficiently to form enough acid carbonate of lime to effect the flocculation.

INJURY FROM LIMING CLAYS.

It is, however, distinctly recognized that the too frequent and copious applications of lime even to clay soils may eventually render them hard and compact, instead of friable and open. In this case, the cementing action of the calcium carbonate formed in the soil appears to more closely resemble that observed in the case of ordinary mortar.

*Chemical News, 1882, p. 53.

†Edw. Vern.-Station, 41, 57.

‡The Soil, pp. 20-21.

A similar injury results from the application of large dressings of caustic lime upon a clay when it is in a wet condition. On very wet clays, draining should precede liming.

MECHANICAL EFFECTS UPON LIGHT SOILS.

Observations upon the influence of lime upon the texture of light soils are more divergent in their conclusions. Many correspondents in this State affirm that the application to light soils makes the latter more retentive of moisture and that this is more true of shales and gravels containing considerable proportions of fine particles than it is of sharp sands or even of alluvial sand deposits. It is noted in particular that the liming of the blue slate uplands of Fulton and Bedford counties has so increased the retentiveness of the soil for moisture, that clover can be made to live through the summer, where, without liming, it dies from drought. These statements accord with experience elsewhere.

EXPERIMENTS UPON THE INFLUENCE OF LIME AND MAGNESIA UPON THE WATER CAPACITY AND HYGROSCOPIC COEFFICIENT OF SOILS.

Upon the several soils under treatment in the experiments conducted in my laboratory, no observations were made to determine the effect of the several treatments upon the rate at which water would percolate through them. But determinations were made by Mr. C. P. Beistle, Assistant Chemist, of the water-holding capacities and the hygroscopic coefficients, or power to absorb water vapor, of the several lots of soil. For the former determinations, the dry soils were weighed into tared glass funnels, upon uniform filter paper, and water was then added until the soils were saturated; when drops ceased to come through the funnel, the tops being covered to prevent evaporation, the funnels were weighed with their contents, and the quantity of water retained was thus ascertained.

For the latter determination, one portion of soil was taken for the estimation of water held under laboratory conditions; another portion was exposed for twenty-four hours upon an open watch-glass in a box so constructed that the air it contained should be saturated with water vapor.

The gain in weight due to the absorption of water, plus the weight of vapor already present, gives, when figured in percentage upon the basis of the dry soil, the hygroscopic coefficient.

TABLE VII—Moisture Relations of Soils.

Soil.	Water-holding Capacity (Per cent.)			Hygroscopic Coefficient. (Per cent.)		
	Blank.	Lime.	Magnesia.	Blank.	Lime.	Magnesia.
I. Ironstone,	46.15	47.53	47.40	3.80	3.59	3.27
II. Black slate,	53.85	54.15	54.40	2.95	2.57	2.94
III. Red shale clay,	47.15	43.53	43.85	1.97	1.73	1.57
IV. Limestone clay,	49.08	51.53	47.15	1.80	1.84	1.33
V. Glacial clay,	45.78	47.53	50.40	1.80	1.85	1.60
VI. Muck,	77.89	53.53	79.40	4.93	4.94	5.22
VII. Limestone clay,	52.89	49.01	51.53	1.53	1.59	1.93
VIII. Loam,	49.36	47.11	50.39	3.37	3.44	3.39
IX. Red shale,	54.38	54.36	54.36	3.23	2.23	2.14

As regards the water-holding capacity, it is to be remarked that the range of difference exhibited by the several untreated soils is not large, viz: from about 46 to 78 per cent.; the muck soil in particular shows a strikingly low capacity; it is entirely possible that in the case of this soil, the porosity was impaired by the sifting through so fine a mesh. The influence of the liming is not clearly marked so far as its influence upon the empty space and arrangement of particles is indicated by the water-holding capacity of the soils; in four instances of varied character, the capacity seems to increase; in five, to diminish slightly; the magnesia exerted as marked an influence, but in samples IV, V and VII, its action was opposite to that of the lime. It is probable that, to exhibit the characteristic change, the conditions of after treatment of the soil have not been favorable. It is hoped to repeat the work under other conditions, but time has not permitted the repetition prior to the preparation of this report. Bearing upon the importance of these conditions, the old observations of Zengar* and Wilhelm† that the pulverization of soils consisting of porous particles such as lime-sinter or peat, to some extent destroys their porosity and power to retain liquid water, may be recalled.

As regards the hygroscopic coefficient, or power to take up moisture vapor, likewise, there is no clear indication that the lime or magnesia exercises any clearly marked influence, and the experiment must be repeated upon portions of soil not treated as those must be which are to be subjected to chemical analysis. Hilgard‡ affirms, however, that this power to take up moisture vapor depends essentially upon one or more of four substances, *humus*, *ferric hydrate*, *clay* and *lime*, named in the order of their efficiency. "It varies," he says, "from 1.5 to 23 per cent. at 150 degrees Centigrade in a saturated atmosphere. A pure clay rarely exceeds 12 per cent.; ferruginous clays show 15 to 21 per cent.; some calcareous clays rise nearly as high; while peaty soil's rise to 23 per cent. or more.

*Wilde's Centralblatt, 1853, 1, 430.

†D. 1866, 1, 113.

‡X Census, 5, 71.

LIME PAN.

One other point of some importance relating to the texture of soils is the tendency noted on stiff soils, the plow depth of which is not varied with some frequency, to form a hard pan or compact layer between the surface and sub-soil. Once formed, it is the tendency of the alkaline silicates, humates and lime carbonate brought to it by the leaching of the surface soil to form a strong layer that prevents the proper upward movement of sub-soil moisture in dry seasons and the free downward movement of the plant roots. Heavy liming, after such a pan is formed, often greatly increases it, forming what is known as lime-pan. This formation is readily prevented, however, by proper liming; but it would be well to be sure that the land is free from hard-pan before heavily liming it.

THE CHEMICAL EFFECTS OF LIMING.

When the action of lime upon various individual minerals and upon distinct organic materials such as starch, albuminoids, etc., is studied, it is found to be quite variable with the nature of the substance acted upon. That the introduction of so powerful a chemical reagent into those highly differing and always complex mixtures of mineral and vegetable matters that we term "soils," should result in a great variety of effects is not, therefore, surprising. In the discussion following, attention will be chiefly confined to a few of the practically more important points, considering first those relative to the mineral matters and, second, those affecting the organic matter (humus) and nitrogenous substances.

MOST SOIL CONSTITUENTS UNAVAILABLE TO PLANTS.

Before speaking in detail upon these subjects, it may be remarked that while plants are able to take up directly from freshly pulverized rock materials small quantities of the several plant foods the latter contain, the mineral substances must usually undergo quite radical changes by the action of weather and decaying vegetation before they are really in condition to make a fertile soil. Before they are thus changed, many of them resist the action of quite strong acids; among such minerals are included the widely distributed and important minerals, quartz, feldspar, mica, hornblende, augite, tale, steatite, kaolinite, chrysolite and chlorite.* It is not, therefore, a matter of

*Johnson, *How Crops Grow*, 329.

surprise that in even rich soils, only 50 to 150 parts in 100,000 are capable of being dissolved in water.

It must, of course, be admitted that the plant is not wholly confined in its feeding upon mineral matters to the water-soluble substances; for the acid surfaces of the rootlets and root-hairs are able to take up some mineral matters through their cell walls in much the same manner as the acid strawberry, in the course of preparation for table use, takes up and is sweetened by the coarse, dry, granulated sugar spread upon it.

We have, however, not discovered a chemical reagent which will closely represent in its action upon the soil, the action of the plant during a single growing season. While it is thought that the mineral matter soluble in hydrochloric acid may fairly represent the ultimate fertility or cropping strength of soils, various organic acids or solutions of their salt have been proposed as reagents to show the more immediately available plant food, such as the plant could probably utilize at once if opportunity occur; these do not all closely correspond in their action with that of various plants, and it is highly improbable that a single solvent could do so for all plants and soils; but they are of considerable value as indicators of the readiness of the various more important soil ingredients for use by the plants, and to afford rough suggestions as to the need for the application of the several manurial constituents.

LIME UNLOCKS PLANT FOOD ALREADY IN SOIL.

So it has come to be said that only a small proportion of the food substances in most soils are immediately ready for plant use; that the less soluble foods are, as it were, locked up in a safe, and that lime is one of the keys by which the safe may be opened and some of its contents made accessible to the crop. If, however, the soil be devoid of compounds such as lime can convert into available plant food, the addition of lime can cause no increase in the material fertility of the soil except as lime itself may be needed by the plants.

LIBERATION OF POTASH.

POTASH IN SOIL CHIEFLY INSOLUBLE.

Though the commercial potash compounds are nearly all soluble—with so few exceptions that the chemical methods for the separation of potash from other bases are very limited in number—most of the

potash present in the soil exists there in insoluble or difficulty soluble combinations. Drainage waters contain, as a rule, much less of it than of soda, lime or magnesia. Thus Way,* upon examining the drainage waters from seven fertile soils near Surrey, Eng., found in four cases, only traces of potash, and in the others, only 0.03, 0.07 and 0.31 parts in 100,000 parts of the water. Krockert† found, in the summer drainage, from poor soils, only 0.2 to 0.6 parts in 100,000 of the water, but Zöller,‡ in five waters of percolation collected during the summer from a number of soils near Munich, found 0.20 to 0.65 parts in 100,000. Dehérain,§ studying the drainage of the experiment farm at Grignon, France, found that on highly manured land the drains in one year removed 0.2 per cent. of the entire acid-soluble potash present, while from unmanured lands, only 0.05 per cent. of the entire amount of potash was removed. Where a proportion of water larger than that found in the soil is used in extraction, or where a soil is exposed to the action of renewed portions of water, larger amounts of potash are found to be dissolved.

POTASH IN FERTILIZERS FIXED BY SOILS.

Furthermore, if a given amount of some potash salt be added to a sample of soil and, after the mixture has stood for a short time, the earth be washed with water and the washings compared with those obtained by the extraction of an equal quantity of the unmixed earth with an equal quantity of water, it is found that the potash extracted from the former soil is far less than the sum of that in the potash salt and that extracted from the unmixed earth; in other words, it is distinctly evident that much of the potash in soluble fertilizer salts is quite promptly changed in the soil into insoluble or difficultly soluble compounds. The time required for the completion of this fixing action—so far as it goes, for all the fertilizer potash is never fixed,—Peters|| found, in case of one soil, to be forty-eight hours.

SOLVENT ACTION OF LIME.

The solvent action of water is, however, very greatly increased when lime, whether as a hydrate, as acid carbonate, or in chlorid, sulfate, nitrate or similar soluble salt, is dissolved in it. The work of Johnson, Way, Liebig, Brustlein, Peters, Knop, Heiden, Armsby and others, has shown most clearly that the lime in such solutions displaces some of the potash of the soil, the displaced alkali being extracted while an equivalent quantity of lime is fixed in the soil. This probably explains the fact noted by Hilgard** that sometimes a

*Jour. Roy. Ag. Soc., 17, 123.

†Jour. prak. Chem., 60, 468; Cf. Johnson, How Crops Feed, §14.

‡Johnson, *Id.* §15.

§Traité de Chimie agricole, 426-7.

||Ldw. Vers.-Stat., 2, 140.

**X Census, 5, 78.

soil very rich in lime and phosphoric acid, shows a good productiveness despite a very low potash content; and, conversely, sometimes a high potash content seems capable of offsetting a low lime percentage—it being true that potash salts when added in solution to a soil, liberate some lime with the fixation of an equivalent amount of potash.

NATURE OF COMPOUNDS ATTACKED BY LIME.

When the nature of the compounds in the soil that are acted upon by the lime with a resulting liberation of potash, is studied, it is found that, for the most part, they belong to two great classes: hydrous soluble silicates, probably belong to the zeolitic class, and double salts of the acids of humus—humates and ulmates. M. Johnstone,* in studying the compounds that result from the weathering of feldspars—anhydrous double silicates of alumina with potash, soda or lime—states that when carbonic acid is present in large quantity, the potash is set free as carbonate; but that when such excess of carbonic acid is lacking, the potash remains in combination with silica; if, then, lime be added, it displaces the potash, forming the lime silicate and setting the potash free, as it has been found to do in acting upon the pure zeolitic minerals.

Mulder† has found that humic and ulmic acids form double salts of the alkalies with lime, magnesia, iron, manganese and alumina. It is doubtless due, at least in large measure, to a displacement of potash by lime in a manner analogous to that observed in the case of the double silicates, that liming soils poor in such silicates but containing humus, results in the increase of available potash.

SOLVENT ACTION OF MAGNESIA.

According to Kellner,‡ magnesia and magnesium salts act in a manner similar to lime. Peters,§ testing the solvent power of the saline solutions of a number of bases, including lime and magnesia, upon equal portions of a well-washed soil, found that the magnesia solution took out 0.1224 grammes of potash, while lime removed 0.1252 grammes, or with a slight correction for the lack of precise chemical equivalence in the solvent used, the magnesia salts had 90 per cent. of the activity of the corresponding lime salt.

AMOUNT OF POTASH IN SOILS EXPERIMENTED UPON.

Turning now to the soils subjected to test in our experiments: The proportion of potash in the solutions prepared for the determinations of lime and magnesia, the results of which have been stated in an earlier paragraph, was determined by Mr. C. W. Norris in accord-

*Naturw. Rundschau, 1891, 323; Exp. Sta. Record, 3, 581.

†Chemie der Acker Krume, quoted by Johnson, How Crops Feed, 2301-1.

‡American Fertilizer, 6, 245.

§Johnson, How Crops Feed, 341.

ance with the official method. To gain a better notion of the availability of the potash in the several soils, Mr. Norris also determined the proportion of potash extracted by water under the following conditions:

One hundred grammes were soaked with 1,000 c. c. of distilled water at summer temperature (23 degrees C., or 73 degrees Fahr.), for seven days, the flask being thoroughly shaken several times daily. The liquid was then drawn off and the fine silt in suspension allowed to settle. In a given fraction of the clear liquid the potash was determined.

In a study of soil solvents made, several years since, by Dr. Bernard Dyer, Chemist to the Royal Agricultural Society, England, upon certain soils of the Rothamsted Experiment Station, England, and checked by the analytical crop and fertilizer records, remarkably indicative results were obtained by using a 1 per cent. citric acid solution as the solvent.

The several soils tested were, therefore, examined before treatment with lime, by the use of this solvent. Mr. C. P. Beistle, Assistant Chemist, made these determinations in the following manner: 200 grammes of the air-dried soil was exposed for seven days at summer temperature (73 degrees Fahr.), to the action of two litres of a 1 per cent. solution of citric acid; the mixture was shaken several times daily. At the end of the seven-day period the liquid was decanted off and carefully filtered. In a given fraction of the filtrate, the potash was determined in the manner recommended by Dyer, save that the heavy metals, phosphoric acid, etc., were first precipitated and filtered off.

The results of these three sets of determinations are given in the following table, the figures being the average of two or three closely concordant determinations:

TABLE VIII.—Potash in the Original Soils. (Per Cent.)

Soil Sample.	Moisture.	In per cent. of the Entire Soil.			In per cent. of the Potash Soluble in HCl.	
		Total.	Citric acid soluble.	Water soluble.	Citric acid soluble.	Water soluble.
I. Ironstone,	2.37	.325	.0133	.0080	4.1	2.5
II. Black slate,	2.00	.385	.0220	.0071	2.5	0.8
III. Red shale clay,	1.39	.460	.0107	.0050	2.3	1.1
IV. Limestone clay,	1.64	.305	.0133	.0063	1.7	0.8
V. Glacial loam,	1.93	.270	.0117	.0071	4.3	2.6
VI. Muck,	4.35	.220	.0450	.0090	20.5	13.2
VII. Limestone clay,	1.33	.340	.0190	.0120	5.6	3.5
VIII. Loam,	1.49	.330	.0150	.0130	4.5	3.9
IX. Red shale clay,	1.73	.415	.0150	.0130	3.6	3.1

The differences in the quantity of water are very small, except in the case of the muck as compared with the other soils; even in the latter case, the correction would be an increase in the percentage of potash in the muck amounting to only one-thirtieth of the portion extracted by the several solvents. Comparisons may, therefore, be made on the basis of the figures as they are stated above. So far as the total amount of potash extracted by strong acid is concerned. No. II, black slate, and No. IV, limestone clay, contain by far the larger quantities, and No. VI, the muck, contains least; while the other soils do not differ very greatly from one another.

The editor of the Handbook of Experiment Station Work (p. 313), notes that this element is capable of great variation without materially affecting the productiveness of the soil. In heavy clay uplands it ranges from 0.8 to 0.5 per cent.; in lighter loams from 0.45 to 0.3; in sandy loams below 0.30., and in sandy loams of great depth may fall below 0.10 with good productiveness and durability.

Hilgard* says "No virgin soil having 0.50 per cent. of potash will wear out first on that side of its store of plant food; and much less will suffice in the presence of much lime and humus."

WATER-SOLUBLE POTASH.

When we turn to the consideration of the condition in which the potash exists in the soil, several striking facts are apparent. The muck, notwithstanding its low proportion of total potash, contains over twice as much water-soluble potash as an equal weight of any other of the soils, and about six times as much as is present in No. III, red shale clay; looking simply at the percentage of the total potash that is present in water-soluble condition, it is seen to be over sixteen times as great in the muck as in Nos. II and IV. On the contrary, the soils containing the highest percentages of potash soluble in strong acid, Nos. II and IV, are among those containing least of this ingredient in water-soluble condition. The source of the soil, as regards the kind of rock from which it is formed, is not necessarily an indication of its present composition and fertility; thus, compare the limestone clays, IV and VIII, and the red shale clays, III and IX, and quite important differences in the amount and condition of the potash are visible.

TOTAL AVAILABLE POTASH.

Turning to a consideration of the potash dissolved by the citric acid method, none of the soils show less than 0.01 per cent., and so should scarcely be regarded as extremely impoverished. Dyer† suggests that there is no immediate need of potash-manuring, if the citric soluble potash in the soil form 0.005 per cent. of the dry soil. In this case, too, the muck shows both the largest percentage and the largest amount, while Nos. I, III, IV and V contain the least amounts.

*Rep. Cal. Exp. Station, 1889, 189.

†Jour. Chem. Soc., 1894.

POTASH IN SOILS AFTER TREATMENT.

The treated soils were also examined with reference to the amount and condition of the potash contained. The total potash soluble in strong acid was determined by Mr. C. W. Norris, that soluble in citric acid solution by Mr. C. P. Beistle. In the latter determination a sufficient quantity of citric acid was used, beyond that required to make a 1 per cent. solution, to neutralize the lime added and magnesia in the samples that represented the results of treatments B and C, so that the neutralizing effect of these alkaline earths might not too greatly interfere with the solvent action of the liquid.

The results are shown in the following table. Owing to the fact that the quantity of the lime and magnesia added in treatments B and C would not, even if fully carbonated by action of the air of the soil, come to equal 1 per cent. of the weight of the entire soil, it has not been deemed needful to correct for the error introduced by this addition, to permit a direct comparison between the results of treatment A and those of B and C. For safety, the moisture of the samples was determined in each case; the difference between the several treated samples and the original soils were, however, so slight that these results may be omitted.

TABLE IX—Potash in the Treated Soils. (Per Cent.)

Soil.	Treatment A. (Fallow).				Treatment B. (Lima.)				Treatment C. (Magueña.)			
	Soluble in strong acid.	Soluble in citric acid.	Proportion of potash soluble in citric acid.		Soluble in strong acid.	Soluble in citric acid.	Proportion of potash soluble in citric acid.		Soluble in strong acid.	Soluble in citric acid.	Proportion of potash soluble in citric acid.	
I. Ironstone, .....	.243	.0123	5.1		.243	.0155	6.4		.323	.0176	8.0	
II. Black slate, .....	.750	.0220	3.0		.753	.0241	3.3		.720	.0246	3.4	
III. Red shale clay, .....	.338	.0116	3.9		.285	.0140	5.3		.345	.0150	4.7	
IV. Limestone clay, .....	.643	.0172	3.3		.573	.0200	3.5		.557	.0178	3.3	
V. Glacial loam, .....	.135	.0122	6.8		.135	.0150	8.1		.225	.0182	7.2	
VI. Muck, .....	.217	.0320	14.7		.310	.0340	16.2		.217	.0334	15.4	
VII. Limestone clay, .....	.315	.0116	3.7		.310	.0162	6.2		.302	.0208	6.9	
VIII. Loam, .....	.386	.0123	3.3		.385	.0144	3.9		.370	.0168	4.5	
IX. Red shale clay, .....	.438	.0134	3.1		.450	.0208	4.6		.448	.0176	3.9	

Examining these figures critically and comparing them with the percentages obtained in the case of the original untreated soils, some very striking discrepancies are seen, especially in the cases of Nos. II, III and IV. Some discrepancy is also apparent in the figures for potash soluble in strong acid obtained from each soil after the different treatments. The latter fact and the further fact that the results are the averages of several separate analyses in each case, lead to the conclusion that the discrepancies are chiefly due to the difficulty in getting perfectly uniform samples of soil, even when great care is exercised.

So far as the potash soluble in strong acids is concerned, there seems to be no evidence in the figures above presented to the effect that the lime or magnesia especially influences the amount of potash that is capable of extraction with such vigorous solvent. There are variations, it is true, in the percentages shown by samples from different treatments of the same soil, but comparing the lime and fallow treatments in their action upon red shale clays, Nos. III and IX, the figures would show exactly opposite effects. It would, however, not be safe on the basis of these analytical results to affirm positively that lime and magnesia have no tendency to attack minerals little soluble in strong acids, and, in greater or less degree, to aid the increase of their availability through the process of weathering.

EFFECT OF FALLOWING.

It may, however, be true that the availability of the potash in the different portions of the same soil is more uniform than is the amount of potash itself. On the basis of this assumption, compare the citric-acid-soluble potash in the original and fallow soils. Despite the opposite tendency of the total potash soluble in strong acid, in soils I, II, III, IV and V, inclusive, after fallow treatment, the proportion of the entire soil present in citric-acid-soluble potash is as great or greater than in the original soils; in the muck soil, the quantity of such potash is materially less in the fallowed soil; in soils VII, VIII and IX it shows a slight decrease; expressed in terms of the entire acid-soluble potash, that soluble in citric acid in the fallow soils is greater in soils I, II, III, IV and V; is somewhat less in soils VII and VIII and markedly less in the muck soil.

EFFECT OF LIMING.

Turning attention now to the effect of lime, recalling that the soils in Treatment A were exposed to precisely the same conditions as those subjected to the other treatments, we may fairly compare the figures from Treatments A and B to ascertain the effect of the liming. Without exception, the "available" potash, or that soluble

in citric acid, was increased. If the proportion of the entire soil represented by the "available" potash is considered, it is found that from 16 to 74 pounds, or an average of 30 pounds per million pounds of soil is present in the limed soil. This may appear to be very little, but as little as twenty pounds of nitrate of soda applied to an acre has been found to influence the plant growth and such application is equivalent to no more than 1 pound of nitrogen to 1,000,000 pounds of soil. The larger effects were observed on the limestone clay, No. VII, and on the red shale, No. IX, which, in their original state, contained nearly 0.3 per cent. of lime. Such increase represents, of course, a larger proportion in case of soils poor in potash.

EFFECT OF MAGNESIA.

Looking finally to the effect of the magnesia as shown by a similar comparison between the figures from Treatments A and C, the "available" potash is increased from 6 to 92 pounds, or an average of 36 pounds per million of soil. In general, the unlocking or liberating of the potash seems to have been about as well accomplished by the magnesia as by the lime. The ironstone soil, No. I, and limestone clay, No. VII, exhibited the most marked effects from the magnesia treatment. Nothing in the composition of the original soil, as revealed by the analyses made, explains its greater effect upon these soils.

Taking the averages for the nine soils, the proportions of the total potash that was soluble in citric acid were: In the original soils, 5.5 per cent.; in the fallow, 5.2 per cent.; in the limed, 6.3 per cent., and those receiving magnesia, 6.3 per cent.

These results, therefore, agree with those of Kellner, viz: That both lime and magnesia increase the available potash in most soils, and that the magnesia is almost equal to its equivalent proportion of lime in producing this effect. It is further interesting to note that this increased availability resulted from the action of magnesia upon the muck as well as upon the soils less richly supplied with humus.

THE EFFECT UPON SOIL PHOSPHORIC ACID.

SOLUBILITIES OF SOIL PHOSPHATES.

The phosphoric acid in most rocks is present in the form of tricalcio phosphate, a lime compound that is somewhat soluble in pure water, and much more soluble in water saturated with carbonic acid gas.

Bretschneider* found that in twenty-four hours at ordinary temperature one part of finely precipitated tricalcic phosphate required 87,832 parts of water to dissolve it, but only 13,181 parts of carbonic acid water. In the soil, however, a very large proportion of the phosphoric acid is present in the form of phosphate of iron (usually ferric phosphate, for the most part) or alumina. The iron phosphate is much less soluble, the same investigator having found that one part of freshly precipitated ferric phosphate requires for its solution 160,625 parts of water, or 146,570 parts of carbonic acid solution. In the latter case it is seen that the solvent action of the soil water, usually containing considerable carbonic acid, is much less, as compared with pure water, than it is in case of the lime phosphate. Fleischer† has found that water dissolves from freshly precipitated phosphate of alumina even less phosphoric acid than it takes up from the corresponding ferric compound.

Johnson‡ remarks that drainage waters commonly contain phosphoric acid but in quantities too small for accurate estimation.

AVAILABILITY IN CALCAREOUS SOILS.

If the soil is rich in lime or magnesia it is thought probable that a fair share of the phosphoric acid will be combined with it and be quite readily dissolved by the plant roots and soil moisture; if, on the contrary, lime and magnesia are deficient, the phosphoric acid is doubtless present in its much less soluble compounds with iron or alumina.

Hilgard,§ in his study of the cotton soils of the Southern States, dwells upon this point. He notes that less than 0.05 per cent. of phosphoric acid soluble in strong acids is a notable deficiency unless accompanied by much lime; in sandy loams, 0.1 per cent., with a fair supply of lime, secures a fair productiveness for eight to fifteen years, but with a deficiency of lime, 0.2 per cent. of phosphoric is required to produce the same result. Three Louisiana soils are cited as illustrative of this fact:

(a) Pine woods sub-soil (Vernon parish) an upland soil producing only 500 lbs. of seed cotton per acre for a few years.

(b) Oak and hickory red sub-soil, upland (Sabine parish), producing 800 to 1,000 lbs. when fresh, then declining.

(c) Anacoco prairie soil (Vernon parish) has yielded 1,200 to 1,500 lbs. for fifteen years and is still doing fairly well.

*Quoted by Storer, *Op. cit.*, (4th ed.), I, 285-6.

†*Id.* 264.

‡*How Crops Feed*, 310-315.

§*X Census*, 5, 78-80.

	(a.) Per cent.	(b.) Per cent.	(c.) Per cent.
Potash,	0.247	0.202	0.332
Lime,	0.097	0.268	1.398
Magnesia,	0.339	0.290	0.786
Phosphoric acid,	0.072	0.038	0.047

The observations of Gerlach,* made upon artificially treated soils, show that the phosphates of both lime and magnesia are slowly soluble in water and completely so in carbonated water; but the phosphates of iron and alumina are practically insoluble in these solvents and only incompletely so in dilute organic acids.

LIME ATTACKS FERRIC PHOSPHATES.

There are quite a large number of observations showing that the application of lime to soils deficient in that constituent tends to increase the availability of the phosphoric acid present. Thus, Dehérain,† on mixing calcium carbonate with ferric phosphate and treating the mixture with carbonic acid water, found much tricalcic phosphate in the solution; if, however, lime phosphate was mixed with a large proportion of ferric carbonate, ferric phosphate was formed.

On the basis of this latter observation, this investigator‡ suggests that unless such considerable quantities of lime are used as will predominate over the free sesqui-oxids of iron and aluminum in the arable layer of the soil, the increased solubility of the soil phosphates will not be accomplished.

Prof. Millot§ observed that the application of soluble phosphates to soil in the department of Loire-et-Cher which was rich in iron oxid. gave a benefit, but one very fleeting, no residual effect being observed the second year; the subsequent addition of marl brought an increase in yield such as that land never yields except with a good dressing of phosphate, indicating the restoration of the phosphoric acid to an available condition. This is a fair type of many such observations.

PHOSPHORIC ACID IN SOILS EXPERIMENTED UPON.

Turning now to the soils taken for experiment: The amounts of phosphoric acid contained in the several solutions made by extraction of these soils, were determined, in the strong acid and water solutions, by Mr. Norris, and in the citric acid solution by Mr. Beistle. In the latter solution, the results are somewhat unsatisfactory because

*Ldw. Vers. Stat., 46, 201.

†Comptes rendus, 46, 212.

‡Traité de chimie Agricole, 525.

§Loc. cit.

of the difficulty of perfectly removing the finest particles of soil from the liquid, so that the phosphoric acid obtained represents that in the small particles of soil as well as in the real solution; in determining the potash, the figures for which have already been presented, the chemical methods that were employed threw out the silt, which was not practicable in determining the phosphoric acid:

TABLE X.—Phosphoric Acid in the Original Soils. (Per Cent.)

Soil Sample.	Percentage in Entire Soil.			Proportion in Available Form.	
	Soluble in strong acid.	Soluble in citric acid.	Soluble in water.	Citric acid soluble.	Water soluble.
I. Ironstone, .....	.080	.0057	.0032	9.5	5.3
II. Black slate, .....	.204	.0111	None.	5.4	0.0
III. Red shale clay, .....	.080	.0088	.0016	11.0	2.0
IV. Limestone clay, .....	.140	.0032	.0033	5.9	2.4
V. Glacial loam, .....	.082	.0130	.0040	14.1	4.3
VI. Muck, .....	.206	.0628	.0015	30.5	0.7
VII. Limestone clay, .....	.124	.0139	.0027	11.2	2.2
VIII. Loam, .....	.127	.0146	.0005	11.5	0.4
IX. Red shale clay, .....	.151	.0306	.0045	20.3	3.0

As for the phosphoric acid soluble in strong acid: Hilgard's average from 466 soils from the humid regions of this country, especially the Southern States, is 0.113 per cent.; from 313 soils from the arid regions, 0.117 per cent.; in general, clay soils were considerably richer than sands. In view of these averages, most of the above soils are fairly well supplied with phosphoric acid, Nos. I, II and V containing least, but even these are not very deficient.

Dehérain* observes that in estimating the sufficiency of the phosphoric acid in a soil, not only its richness as exhibited by analysis, but its depth must be considered in determining the need for phosphatic fertilizers. Thus, he says, M. Nantier, director of the Agricultural Station of Somme, found, near Amiens, a soil containing 0.25 per cent. of phosphoric acid, of which much was available, as shown by the solubility of one-tenth in acetic acid; yet a phosphate dressing increased the yield per acre (French) of beets from 28,500 to 45,000 kilogrammes; for the soil was only from six to eight inches deep, and had scarcely more available phosphoric acid in that depth of soil than one crop would require. He suggests that unless a soil contains more than 0.1 per cent. of phosphoric acid, and more than 0.02 to 0.03

*Traité de Chim. agricole, 730-1.

per cent. of available phosphoric acid, with such depth of surface soil that the amount of available acid therein shall not be less than about 900 lbs. per acre, phosphate manuring is needed.

AVAILABILITY OF THE PHOSPHORIC ACID.

The condition in which the phosphoric acid exists in the several soils is evidently very different; thus, samples II, VI and VIII, despite their comparatively high proportion of phosphoric acid, contain very little that is soluble in water, even less than III, which contains so much less of phosphoric acid as a whole. In No. I, which contains the least of all, there is the largest proportion of the phosphoric acid soluble in water.

Considering the total available phosphoric acid as indicated by the proportion in the entire soil soluble in citric acid, the muck is richest and the red shale clay, IX, next, while the ironstone, I, contains least. Only I, III and IV contain less than 0.01 per cent., the figure fixed by Dyer as indicating need of immediate phosphate application.

PHOSPHORIC ACID IN SOILS AFTER TREATMENT.

The effects of liming and application of magnesia upon the availability of the phosphoric acid are shown in the following table:

TABLE XI—Phosphoric Acid in Treated Soils. (Per Cent.)

Soil.	Treatment A. (Fallow).			Treatment B. (Lime.)			Treatment C. (Magnesia.)		
	Soluble in strong acid.	Soluble in citric acid.	Proportion of phosphoric acid available.	Soluble in strong acid.	Soluble in citric acid.	Proportion of phosphoric acid available.	Soluble in strong acid.	Soluble in citric acid.	Proportion of phosphoric acid available.
I. Ironstone, .....	.095	.0032	8.6	.003	.0107	10.9	.009	.0098	9.7
II. Black slate, .....	.227	.0100	4.4	.223	.0090	3.9	.205	.0100	5.3
III. Red shale clay, .....	.089	.0080	9.0	.064	.0107	13.7	.090	.0110	13.8
IV. Limestone clay, .....	.147	.0064	4.5	.139	.0132	10.3	.154	.0135	7.7
V. Glacial loam, .....	.097	.0100	11.0	.083	.0129	15.0	.090	.0184	13.2
VI. Muck, .....	.206	.0498	24.1	.221	.0374	24.3	.241	.0610	25.3
VII. Limestone clay, .....	.124	.0090	7.3	.129	.0133	9.7	.133	.0183	9.3
VIII. Loam, .....	.133	.0064	5.5	.131	.0124	7.7	.135	.0189	11.3
IX. Red shale clay, .....	.135	.0173	13.3	.153	.0253	16.9	.145	.0230	21.1

While differences in the total phosphoric in the original soil and the corresponding treated soils are observed, just as was the case with potash, the general relations are the same in both the original and treated soils.

EFFECT OF FALLOWING.

Comparing the original and the fallow soils, as regards the proportion of the phosphoric acid in available condition, the latter shows an invariably smaller proportion than the former; this is not always very marked, but in some cases, such as III, V, VI, VII, VIII and IX, for instance, the decrease is considerable.

EFFECT OF LIMING.

Compared with the fallowing, the treatment with lime results in a larger availability of the phosphoric acid than where soil lies fallow, except in the case of II; it is possible that a predominance of iron and alumina in the latter soil may account for this, but as no determinations of iron and alumina were made, it is not certain that this is the correct explanation. On the muck, the liming seemed not to have caused any increase in the availability of the phosphoric acid or to have entirely prevented a decrease; the greatest increases occurred in soils IV, V and IX.

EFFECT OF APPLYING MAGNESIA.

Considering the effect of magnesia, its general tendency was to act as powerfully, at least, as lime. Indeed, if we may form an estimate of the influence of the different treatments upon the availability of phosphoric acid, the following averages will be suggested: Of the total phosphoric acid, the citric acid took from the nine soils by Treatment A, 9.7 per cent.; by Treatment B, 12.5 per cent.; by Treatment C, 14.0 per cent. While inference from averages is not always safe, it does not seem that lime acted in these cases more effectively than magnesia; in soils V, VIII and IX the increase with magnesia was much the greater, while IV showed a considerably less effect than lime. As in the case of lime, soils II and VI alone failed to show a marked increase in the availability of the phosphoric acid.

INFLUENCE UPON SUBSEQUENT APPLICATION OF PHOSPHATES.

There is another important consideration in the use of lime, viz: Its influence upon the immediate availability and upon the duration of effect of phosphatic fertilizers applied to a limed soil.

REVERSION OF PHOSPHORIC ACID IN FERTILIZER.

It is a well-known fact that in the manufacture of super-phosphates, if the soluble phosphoric acid, or rather water-soluble phosphates

formed by the action of sulfuric acid upon tricalcic phosphate, the so-called "bone phosphate of lime," be brought into contact with wood ashes, lime or even fresh portions of raw phosphates, the soluble compounds will be wholly or in part reverted or reconverted into tricalcic phosphate, differing from the original only in being more finely sub-divided than is possible by a purely mechanical process. The chemically precipitated phosphate is much more soluble than that occurring in nature; thus, Warington* found that, at ordinary temperatures, there were required of water saturated with carbonic acid gas, to dissolve one part of pure precipitated tricalcic phosphate, 1,789 parts; to dissolve one part of the phosphate of lime in bone ash, 6,788 parts. Voelcker† found that 4,900 parts of water dissolve one part of pure precipitated tri-magnesia phosphate, while 12,610 parts were required for similarly prepared tricalcic phosphate.

REVERSION IN SOIL.

Now, it is clear that very shortly after their introduction into the soil, soluble phosphates must be converted into less soluble compounds, whether of lime, magnesia, iron or alumina, unless the soil be one containing neither the earthy carbonates nor the oxids of iron and aluminum. Such soils are very rare. Farsky‡ found that in twenty-four hours, over 60 per cent. of the water-soluble phosphoric acid of acid phosphate applied to a certain soil had lost its capacity of solution in water. In such cases the principal advantage of acidulation of the phosphate must be found in its more thorough dissemination in the soil and in the finer state of subdivision obtained than can be secured by the mechanical pulverization and stirring in of raw phosphates.

IN NON-FERRUGINOUS SANDY SOILS AND PEATS.

In non-ferruginous sands and peaty soils, the addition of lime would result in a quicker conversion to less soluble form, of any acidulated phosphate later applied. In the absence of lime, this "fixation" would not occur and while the soluble phosphate could be somewhat more promptly taken up by the plant, it is far more likely to lose by leaching and to cause injury to the crop by over-concentration. Soils that are artificially deprived of basic material by action of strong acids, exhibit a similar inability to "fix" phosphoric acid.

IN FERRUGINOUS SOILS.

In the absence of lime or magnesia, there is a tendency to immediate union with iron oxid or alumina, with the result of an almost

* Cf. Storer, I, 362.

†Loc. cit.

‡Rep. Pa. Agr. Exp. Station, 1887.

immediate loss of availability. It is, therefore, urged in behalf of lime and magnesia that their presence results in a far greater duration of effect from super-phosphates than could otherwise be secured; and their application to a non-calcareous soil must greatly increase the value of later applications of soluble phosphates as well as increase the availability of the phosphatic compounds already present in the soil.

Kellner, Sakano, Sato and Shinjo* found that lime added to a deep, yellow sub-soil of an irrigated field did not prevent the quick conversion of a subsequently applied dressing of water-soluble phosphate into a form not capable of solution in neutral ammonium citrate. This may have been because the quantities of lime applied (equivalent to from 0.25 to 5.0 per cent. of the soil) may not have equalled the oxids of iron and alumina present. On a "paddy" soil of the same geological origin, but rich in organic matter, the lime retarded the formation of the insoluble phosphates, especially where the proportion of lime was over 1 per cent. of the air-dry soil. Kellner believes, however, that the humus of the paddy soil is useful in accomplishing part of this retardation.

IN CALCAREOUS SOILS.

Voelcker† notes that heavy dressings of rich super-phosphates are not nearly so valuable on the sandy soils of England as on calcareous soils.

CHOICE OF PHOSPHATES FOR DIFFERENT SOILS.

Dehérain‡ urges that long cultivated soils are those for which soluble phosphates are best adapted. On old, non-calcareous soils he regards the basic slag phosphates, which themselves contain lime in caustic or carbonate form, as preferable; and only on old grass lands newly cultivated or on virgin soils rich in organic matter does he recommend the *trial* of non-acidulated phosphates. Bernard,§ upon the basis of numerous observations as well as upon theoretical considerations, strongly advocates the same selection.

LIMING INCOMPATIBLE WITH USE OF NON-ACIDULATED PHOSPHATES.

Speaking of the use of lime with raw phosphates, Dehérain** observes that the latter should never be used simultaneously with lime, since the latter will prevent the solvent action of organic acids upon the phosphates. In France, where non-acidulated bone-black used to be employed as a fertilizer, it was found to yield no benefit either

*Bulletin No. 9, College of Agriculture, Tokio, Japan; Exp. Sta. Record, 2, 764-5.

†Quoted by Storer, II, 236.

‡Traité de Chim. agricole, 769-770.

§Le Calcaire, 91-120.

**Op. cit., 760-761.

with or after a liming; if, however, the liming follows a year later, an increase in the efficiency of the phosphoric acid, by that time partially changed to the iron and aluminum compounds, was exhibited, from causes already explained. These remarks apply better to raw lime phosphates than to those of iron or alumina.

FIXATION BY MAGNESIA.

Kellner* claims for magnesia also a strong influence in retarding the reversion of phosphates in the soil.

INFLUENCE OF LIME UPON THE WEATHERING OF ROCKS.

DOUBLE SILICATES INFLUENCE SOIL RETENTIVENESS.

In discussing the effect of lime as a liberator of potash in the soils, it was noted that among the minerals most largely attacked were the hydrous double silicates of potash and alumina. The investigators mentioned in that connection have found that, commonly, an excess of a potash salt or ammonium salt is capable, when introduced into a soil containing a hydrous double silicate of lime and alumina of displacing the lime and leaving the potash or ammonia fixed in the silicate. It is obvious that the presence of a goodly proportion of such double silicates must contribute very largely to that store of fertility which, if not at once fully available, come into activity in response to good tillage and enables the soil to withstand the drain of heavy, continuous cropping; and, also, to the ability of the soil to take up and retain in fairly available form, without undue waste by leaching, such heavy dressings of potash and ammonium compounds as it may receive—a property often lacking in lighter soils.

LIME PROMOTES WEATHERING AND FORMATION OF DOUBLE SILICATES.

Numerous investigations show both directly and indirectly that lime greatly promotes the weathering of minerals; thus, making their constituents available to the plant, and especially contributes to the formation of this valuable class of soil components, the double silicates. A little of the evidence bearing particularly upon this latter point may be of interest.

Hydraulic cements are found to contain large quantities of hydrous double silicates of lime and alumina; the setting under water is at-

*American Fertilizer, 6, 245.

tributed to the formation of crystals of these compounds as they complete their hydration. These cements can be artificially made by mixing certain clays of volcanic origin, or burned clays with moist lime. Many clays which themselves show little tendency to be acted upon by hydrochloric acid, as the hydrous double silicates readily are, are largely decomposed by it after having been exposed for a week or two to the action of milk of lime.

Storer* notes the fact that old mortars are often found to contain notable quantities of hydrous silicates, so that caustic lime must be able to attack even the strongly resistant grains of sand. In the same connection, he presents the results of experiments by Stöckhardt proving that lime attacks powdered quartz as well as gelatinous silica, forming a hydrous lime silicate, and that it also decomposes powdered feldspar—a mineral which resists the action of strong acids. Liming is said to be especially efficacious upon such clays as contain broken but undecomposed fragments of feldspar.

By this increase of weathering, therefore, not only is the amount of free potash made more abundant, but the retentiveness of the soil and its durability are at the same time enlarged.

Indeed, numerous laboratory experiments show that many soils gain, by admixture of lime or lime carbonates or other of its salts, greatly in their power to fix potash, soda, ammonia, etc.

It is, furthermore, evident that the liming of sandy soils, especially of those largely made up from minerals other than quartz, in addition to any value it gives in a direct contribution to the food supply in the soil, must also tend to secure a most important benefit in increased retentiveness for added fertility, a property in which such soils are very deficient.

IMPORTANCE OF LIME IN CLAY-BURNING.

The expensive process of clay-burning so much used upon certain soils of England and Germany, a few decades since, was unproductive of any beneficial results, Lloyd states, unless lime was present in the clay. Storer† asserts, however, that all plastic clays are benefitted in texture if properly burned, but that those containing lime are most benefitted. Voelcker‡ found that a clay containing 31.38 per cent. of calcium carbonate and 58.62 per cent. of real clay gave the following results, in terms of the entire soil:

*Op. cit. II, 150.

†Op. cit., II, 280-1.

‡Quoted by Storer, I, 233.

	Total acid soluble.	Potash soluble in acid.
Before burning,	Per cent. 44	Per cent. 0.56
Moderately roasted,	49	0.77
Properly roasted,	54	.....

Similar results were obtained on other soils by other investigators. Undoubtedly, therefore, one of the most important beneficial results from this treatment is found in the increased proportion of alkaline silicates and more highly available potash in the soil.

REACTIONS UPON THE SOLUBLE SALTS OF POTASH AND SODA.

Potash and soda are contained in soils not alone in the form of anhydrous and hydrous silicates, but also to a greater or less extent in the form of soluble salts. Upon this class of compounds, as well as the former, lime reacts with important results.

LIME AND SALT COMPOSTS.

The use of salt with lime in composting peat and other vegetable matters has been largely practiced. The lime decomposes the salt, forming calcium chlorid and caustic soda; the latter of the two resulting compounds being the more readily diffusible, separates in a porous compost from the chlorid and reacts more powerfully than caustic lime in decomposing the vegetable matter. Prof. S. W. Johnson* found a compost of peat and ashes, with lime in one case, and lime and salt in another, gave crops of pop-corn of 43.22 and 46.42 grammes weight respectively, showing the superior activity of the latter agency for decomposition.

Storer† suggests that this may afford a possible explanation for certain exceptionally good results obtained from dressings of salt applied to limestone soil, the soda compound formed in this case being

*Cited by Storer, *Op. cit.*, II, 19.

†*Op. cit.*, II, 168-9.

the carbonate, however, rather than the hydrate, or caustic soda. A similar reaction would take place with potash salts.

LIME AS A PREVENTIVE AGAINST INCRUSTATION.

Heinrich* notes than a frequent consequence of heavy applications of soluble fertilizers (kainit, nitrate of soda, etc.) to the soil is the formation of troublesome crusts upon the surface that are only temporarily remedied by cultivation, the next rain being followed by a reappearance of the crust. The simultaneous use of lime, preferably in the form of carbonate, with such fertilizers, is recommended by him as a very excellent preventative against the incrustation.

Lime and calcareous marls have also been found valuable as corrections for the white alkali soils of the arid regions of the west, when these soils contain much of the sulfate or chlorid of magnesium and similar salts.

EXCESS OF ALKALINE HYDRATES AND CARBONATES MAY WORK INJURY.

It may easily happen, however, that the alkaline hydrates or carbonates that prove such valuable aids in decomposing humus, may occur in such excess as to cause decided injury. It is a well established fact that these materials have an influence upon the texture of clay soils opposite to that of lime, causing such a soil to puddle, become plastic and remain moist. Even on light, sandy soils, heavy dressings of wood ashes have produced such a degree of coherence between the particles as to make plowing a difficult matter. In the "black alkali" soils of California, Hilgard† has found large quantities of sodium carbonate and, in consequence of its influence, these soils are most refractory; furthermore, in the great excess in which the salt is present, it seems to work corrosively upon the vegetation that starts growth upon these soils.

It is entirely possible, therefore, that the reactions between the alkaline salts and lime, either the hydrate or carbonate, that occurs when large dressings of lime are applied to lands heavily impregnated with these salts, or when the latter are applied in large quantities to clay lands rich in calcium carbonate, may produce so large quantities of the sodium or potassium hydrates or carbonates as to work injury. Indeed, Heinrich‡ states that he has, in two instances, observed injurious results from the application of marl (used because of the calcium carbonate it contains), once upon land in whose neighborhood a deposit of salt was later discovered, and once upon soil that had received heavy applications of sewage, which is always rich in common salt.

*Mergel u. Mergeln, 13.

†Bulletin 3, U. S. Weather Bureau.

‡Op. cit., 16.

LIME CORRECTS HARMFUL INFLUENCE OF FERROUS SALTS.

There are often found in such soils as are shut off from free access of air, such as stiff sub-soils and undrained swamps and moors, ferrous compounds produced probably by the reduction of ferric salts or ferric oxides and hydrates. Even after swamps and marshes have been reclaimed, it is probable that in the presence of the large amounts of organic matter such lands contain, there can not be an immediate, complete oxidation of such compounds to ferric forms. Maercker* asserts that the presence even of considerable quantities of ferrous oxid does not necessarily render moor earth uncultivable, so long as the iron remains in insoluble combinations, such as a double ferrous and calcic humate, for example.

While it is true that the humates and ulmates of iron are nearly insoluble in water, Mulder† found the ferrous compounds of apocrenic and crenic acids to be soluble. Since, therefore, the latter compounds are likely to occur in sub-soils and marshy lands, it is not improbable that a part of the marked infertility of fresh turned, yellow clay sub-soils and of recently drained marsh lands is due to these compounds as well as to the sulfates, whose action will be discussed later.

The cause of their injurious effect is not fully understood. The more commonly accepted theory attributes the ill effect to the avidity with which they take up oxygen, robbing the plant roots of their requisite supply.

If such soils be limed, the iron is thrown down in an insoluble form and may then be slowly oxidized without working so great injury to vegetation.

LIME CORRECTS SOIL ACIDITY.

FORMATION OF SULFIDS IN SOILS.

In discussing the sources of the lime present in our limestone formations, mention was made of the fact that in the waters of certain

*Quoted by Storer, I. 486.

†Quoted by Johnson, How Crops Feed, 281.

springs and in the mud of the sea bottoms, calcium sulfate is being constantly reduced to the form of sulfid, largely through the agency of living organisms. A similar reduction of the sulfate of lime and ferrous sulfate occurs when they are in contact with large proportions of decomposing organic matter. Dehérain,* applying gypsum (sulfate of lime) to soils of varying richness, found after a month that from a soil moderately rich in organic matter, 0.55 gr. of sulfuric acid had disappeared, from a soil containing more humus, 0.100 gr., and from a marsh soil, 0.347 gr.

SULFIDS OFTEN OXIDIZE TO INJURIOUS SULFATES.

These sulfids sometimes decompose, under the influence of carbonic acid, with the formation of the corresponding carbonates, the sulfur going off in the form of sulfuretted hydrogen. But in many marshes, bogs and moors they accumulate, the iron sulfid in particular.

These sulfids appear to be directly injurious to plants, but it is probable that a large part of the damage they work is due to the sulfuric acid and ferrous sulfates they form when oxidized. For Farsky† has shown that the direct addition of free sulfuric to soils is injurious to vegetation, and Mulder‡ found that humic acid liberates sulfuric acid from ferrous sulfate.

OCCURRENCE IN MARSH LANDS.

In the reclamation of the sea bottoms practiced in Holland, the injurious action of sulfids and sulfates has been experienced and it doubtless occurs to some degree in all cases of reclamation of tide-water marshes, and of the bottoms of quiet pools and dams. It is noted, in the management of the old Acadian dyke-lands of Nova Scotia, which are flooded every few years and then again drained, that after such renovation the lands remain almost entirely unproductive for a year or two. It is possible that this is due in part to the sulfids, as well as to the sea salts taken up by the earth.

OCCURRENCE BELOW COAL STRATA.

There are many limited areas in Pennsylvania lying just below and receiving the leachings from the coal outcrops and the contiguous slate strata, that are almost wholly unproductive because of the ferrous sulfate and sulfuric acid formed by the oxidation of the iron pyrites in the coal and slate and seeping into these lower soils.

INJURIES BY MINE WATER.

There are also in our State hundreds of acres of once fertile river and creek bottom lands, through which pass streams receiving mine

*Traité de Chim. agricole, 546-7.

†Bled. Centralbl., 1886, 453.

‡Chemie der Ackerkrume, II, 37.

waters charged with free acid, ferrous sulfate and pyrites-containing culm, that have become sterile because of deposits of the culm upon their surface and the percolation of the acid waters into their pores. Even where the layer of culm is not heavy, the sulfates and acids formed from the pyrites often prove wholly destructive to all valuable vegetation, wild blackberries, dewberries and certain weeds taking the place. Coming upon light, sandy alluvium not very rich in lime or magnesia at the outset, such deposits work an injury that is permanent through many years, and sometimes utterly destructive if the land be left to the corrective action of natural agencies.

LIME AS A CORRECTIVE.

If, however, lime, either in the caustic condition or as carbonate, be applied to such lands, the free acid is at once neutralized and the ferrous salt soon decomposed into harmless compounds, and even the pyrites more rapidly converted into non-injurious ferric oxid and calcium sulfate. Magnesium hydrate or carbonate would also promptly neutralize the free acid and decompose the ferrous salts.

Such dressings of lime might not be very effective, however, in case of lands injured by mine-water, if the acid water were constantly rising by percolation from the sub-soil, or if the surface soil were so situated as to receive frequent and large deposits of culm.

LITMUS TEST FOR SOIL ACIDITY.

If the "burning" and partial or entire failure of good grasses, clover, and cereals upon the soil and the substitution of the characteristic vegetation above mentioned, is not an entirely conclusive proof of the nature of the injury, a direct chemical test may be made to determine whether or not the soil is acid. It must be frankly admitted that the existing tests used for this purpose are not as delicate and conclusive as is desired, owing, in large measure, to the action of the carbonic acid which is to some degree present in the air and moisture of most soils; consequently, the detection of slight acidity is a matter of uncertainty even when the test is applied by an experienced chemist.

The litmus test is one applicable to soils devoid of humus as well as to those rich in that constituent. Litmus is a vegetable dye which turns to a very pronounced blue tint in alkaline solution, and to a bright to pinkish red in acid solution. It is most conveniently applied by means of strips of paper dyed with the coloring matter. A few cents' worth of the blue litmus paper should be purchased from the druggist, and with as little handling as possible, placed in a stoppered or corked bottle and kept in the dark, because sunlight causes the tints to fade. The most satisfactory method proposed for applying this test is that of Dr. H. J. Wheeler:* "A tablespoonful

*Bulletin 46, R. I. Exp. Sta., pp. 100-101.

or more of soil is placed in a tumbler or cup and moistened with sufficient water to make the mass of about the consistency of thick paste; allow it to stand for fifteen to twenty minutes before making the test. With a knife-blade part the soil and insert one end of a strip of the paper, press the soil about the paper and after two to five minutes remove the paper without tearing it; rinse off the adhering soil with water and note whether it still retains a blue tint or has become positively red. If the soil has a reddish tint, it may be better to bring but one side of the paper into contact with it, and if a red color comes through to the other side it may be concluded that the soil is acid. Care must be taken not to handle the end of the paper used in making the test, since the touch of the fingers may redden it." Fresh-boiled and cooled rain water is best employed for moistening the soil. If there be much carbonic acid in the soil moisture, a permanent wine-red color may be obtained; but this is not indicative of injurious acidity. If a drop of very dilute vinegar be brought upon the paper, it will give the kind of tint that an acid soil imparts, though the latter is often fainter. Any soil giving this tint needs an alkaline treatment; if the acidity is very slight, it may be temporarily corrected by use of well-rotted stable manure, but if considerable, requires the more powerful and permanent action of lime, caustic or carbonate.

ACIDITY FROM FERTILIZERS.

It sometimes happens that an acid phosphate applied to a non-calcareous soil, or in large quantities, to one moderately rich in lime or magnesia, or upon very dry soil, or with very imperfect admixture with the soil owing to the manner of application, produces a temporary acidity in the neighborhood of the germinating seed or young cuttings, with the result that they are "burned" and often killed. On highly calcareous soils or on such as have recently received a moderate dressing of lime, such injury is far less frequent. Also, there was placed upon the market, about twenty years ago, an imperfectly prepared sulfate of potash, which was really an acid sulfate of potash; it wrought injury in the same way. There is little, if any, of this preparation now on sale, as a very simple method of preparing a safe product from the imperfect material has been discovered.

ACIDITY CAUSED BY SELECTIVE ABSORPTION OF BASES BY PLANTS.

A third cause affecting the soil reaction is found in the power which plants possess of selective absorption of the base or acid of a salt, leaving in the soil the unabsorbed residue. There are several views as to the point at which the decomposition of the salt actually occurs, but the fact of such selective absorption is thoroughly established. This was first noted by Stohmann and, later, Kühn*

*Henneberg's Journal, 1864, pp. 116 and 126.

found that upon growing maize in solutions containing ammonium chlorid, the ammonia was absorbed, leaving a residue of hydrochloric acid in the liquid that accumulated to such strength as to kill the plants. In other cases, such as those of tri-calcium phosphate or sodium nitrate, the plant tends to use more of the acid than of the base, leaving the latter in the soil. Adolph Mayer* groups the more important fertilizer compounds according to their result upon soil reaction as follows:

Neutral: Calcium sulfate (gypsum), magnesium sulfate, sodium chlorid (common salt), super-phosphate and potassium nitrate.

Acid: Potassium chlorid (muriate of potash), ammonium sulfate, potassium sulfate and German potash salts in general.

Basic or alkaline: Calcium carbonate, wood ashes, caustic lime, potassium carbonate, undissolved calcium phosphate, sodium nitrate (nitrate of soda) and bone meal.

The kind of selection made varies also with the plant; thus, wheat and clover grow with roots intermixed, yet the former takes up more of silica than any other ash constituent, while clover retains little of this acid compound but accumulates the bases, lime being the most characteristic.

It must not be inferred from the foregoing statements that, given a sufficiency of food supply, the plant is wholly uninfluenced in its ash composition by the nature of the soluble materials in the soil, for all plants seem to take up, under such circumstances, an excess of the soluble salt without making any use of it in tissue formation.

ACIDITY FROM HUMUS.

A fourth and the most general cause of soil acidity is the acid humus resulting from the decay and slow oxidation of the vegetable matter, leaves, stubble, roots, inverted sod or green manures in the soil. The formation of the common plant acids, oxalic, tartaric, citric, etc., is the result of oxidations within the plant. Sugar, starch, gums and woody matters form, under the action of oxidizing chemicals or ferments, acetic, lactic, saccharic, mucic and oxalic acids; and when the same substances are acted upon by boiling hydrochloric acid or strong potash lye, brown or black substances are formed closely resembling those that are extractible by the aid of alkalies, caustic or carbonated, from most soils, and separable from these extracts when the latter are made slightly acid. When thoroughly washed, these precipitates are found to be distinctly acid and capable of decomposing some mineral salts. The acid from dark peat is almost black in color and is called *humic acid*; that from brown peats and ordinary soils is commonly brown and is termed

*Law. Vers. Stat., 23, 94-5.

ulmic acid; there are other more highly oxidized acids present, but more difficultly separable, known as apocrenic and crenic acids, and many others are present in minute quantities. It is very doubtful whether the true nature of these acids of the humus has yet been ascertained, since their separation in a pure state is very difficult. Fremy,* on the basis of its composition and solubility in alkaline carbonate solutions, believes humus to be derived from the ligneous matter or *vasculose*, as he terms it, of the woody tissues that have suffered incomplete oxidation in the soil. Whatever may be the true solution of its origin and constitution, these facts are clear: That the organic matters of the soil undergo a gradual oxidation whereby vegetable tissues lose all appearance of structure, acids are formed and, if conditions favor, are finally completely oxidized to form water, carbonic acid gas and certain nitrogenous compounds. If the access of air be imperfect, as when the soil is low and filled with standing water, the humus may accumulate; in cold climates this is especially the tendency, as the mossy tundras of British North America, the heaths of Scotland, the moors of North Germany and the bogs of Ireland witness; but in warmer latitudes, as along the Amazon, the decay is so rapid that a few years suffices to remove all traces even of a giant tree trunk felled to earth.

In low, wet swamps and marshes where the alkaline and calcareous matters are deficient, the result is, of course, that acids form far in excess of the neutralizing power of the bases present. A similar result may occur temporarily where a heavy green-manuring crop is turned under by the plow in a non-calcareous soil or in a calcareous soil with which it is incompletely mixed from lack of proper tillage.

The free acid in such cases is not wholly composed of these humus compounds, for both humic and ulmic acid have been found by Eichhorn† to possess the power of uniting with the bases of the common neutral salts of the alkalies and alkaline earths, liberating their mineral acids; this reaction is rarely complete, however, a portion of the free acidity being directly due to humus acids.

The free acid is injurious to valuable grasses and most cultivated crops, both directly and indirectly, by affecting the bacterial life in the soil, upon which many of its desirable changes depend, and by bringing into solution poisonous ferrous compounds.

Most cultivable soils are faintly acid, owing to the presence of carbonic acid in the soil moisture, but any excess of acidity due to the four causes just considered is highly prejudicial.

LOWLAND ACID SOILS.

Owing to the fact that marshes and swamps naturally occupy low positions and that, owing to the tendency of lime to pass by leaching

*Of. Dchérain, *Traité de Chimie agricole*, 241 seq.; 393.

† . Storer, I, 482.

from the table lands and slopes to the valleys, the occurrence of decidedly acid lowland soils, even among woodlands, as Tacke* has shown, is quite rare, it has come to be generally thought among agricultural writers that soil acidity is a subject requiring little consideration.

UPLAND ACID SOILS.

When it is recalled, however, that many soils are derived from rocks poor in lime, such, for example, as certain granites, and that the lime, even of a soil originally rich in that constituent, is sometimes almost wholly removed by leaching from an upland, it is not surprising that a careful examination of soils so situated reveals many instances of markedly injurious acidity. Thus, Muntz and Girard† mention large areas of sandy soils in Brittany, Limousin and other sections of France as distinctly acid; Schultz-Lupitz‡ states that the sandy soil in his section of Germany is deficient in lime and sour, and Ditmar§ and Hübner|| mention the frequent acidity of sandy soils; Hilgard** has noted such acidity in the sandy uplands of the Southern States and Ruffin†† long since noted the occurrence of extensive tracts of that character in Virginia, while Wheeler and his associates have made certain the acid character of large areas of Rhode Island and Southern Massachusetts, whose soil is of granite origin.

Upon considering that the major portion of the uplands in Pennsylvania are composed of soils derived from geological formations that are not conspicuously calcareous, and also that the vegetation characteristic of many of these upland soils is made up of distinctly calcifuge plants, such as the chestnut, hemlock, etc., it may be confidently anticipated that a careful examination of these soils would reveal the existence of many tracts rendered infertile by reason of acidity.

AMMONIA WATER TEST.

Wheeler‡‡ gives another useful test based upon the fact that ammonia water remains nearly colorless in contact with the humates or ulmates of lime and magnesia, but forms a dark colored solution, usually brown or black, when these alkaline earths are not present in sufficient quantity to neutralize the humus acids.

The test is made by introducing some of the soil to be tested into a small bottle, partially filling the latter with rain water, adding a few drops of strong ammonia water, corking the bottle, shaking and allowing the soil to settle. The reaction is not always immediate,

*See p. 64. †Les Engrais, III, 120-121. ‡Die Kalidüngung auf leichten Boden, 25. §Ldw. Vers. Stat., 14, 277. Schulze's Lehrb. Chem. Landw. (4th ed.), 538. **X Census, V, etc.: All quoted by Wheeler, ††Rep. R. I. Agr. Exp. Sta., 1896, 232 seq.

‡‡R. I. Agr. Exp. Station, Bull. 46.

sometimes requiring several hours for its completion. The presence of a faint yellow color is not to be regarded; but if the tint be dark yellow, brown or black, the presence of acid humus is indicated.

ACTION OF LIME ON MUCK SOILS.

The application of lime very quickly corrects the acidity of drained swamps and marshes, and large applications are sometimes made upon new soils of this character in fitting them for the growing of vegetables, such as onions, celery, etc. The heavy yields resulting from the action of wood ashes, derived from burning brush-heaps, upon newly cleared timber lands are, often, in part attributable to such destruction of a mild acidity. Where the practice of applying peat for fertilizing land is practised, it has long been noted that the raw or crude peat frequently works injury instead of benefit; if, however, the peat be allowed to drain and season for some months, the injurious effect is decreased. The mere weathering of the peat may result in oxidizing any sulfids and ferrous salts contained and improve its texture, but could scarcely correct its acidity; if, however, the peat be composted with lime, the acidity is promptly corrected and the compost is very soon in readiness for use.

The following pot experiment made by Johnson* shows the effect of such treatment upon the crop obtained:

Soil.	Compara- tive weight of crop.
1. Peat alone,	1
2. Peat and ashes,	8
4. Peat, ashes and slaked lime,	19

ACTION OF LIME ON LIGHT ACID SOILS.

Some pot experiments by Wheeler† show the relative effect of air-slaked lime, which neutralizes humus, and calcium sulfate, which has no such power. Upon light, acid soils dressed, in addition, with (a) nitrate of soda and muriate of potash and with (b) nitrate of potash respectively, the percentage of gain from the use of lime over that of the land plaster or calcium sulfate was as follows:

*Peat and Its Uses; quoted by Storer, II, 19.

†Rep. R. I. Agr. Exp. Stat., 1896, 269.

	(a)	(b)
Sugar Beet:		
Roots,	207.52	33.15
Tops,	124.06	46.19
Table Beets:		
Roots,	96.05	56.92
Tops,	30.47	30.30

Clearly, the lime had a most important effect in neutralizing the acidity, and the selective absorption exercised by the sugar beet left a considerable residue of mineral acid in the soil.

MAGNESIA AS A NEUTRALIZING AGENT.

As for the effect of magnesia in correcting acidity, the remark of Low* that magnesian lime is especially efficient upon peaty soils may be recalled; this efficiency may arise from the fact that under favorable conditions for chemical combination, 71 pounds of magnesia can unite with as much as acid as would require 100 pounds of pure lime. Kellner† commends its efficiency as a neutralizing agent for acid soils. Dehérain‡ refers to the magnesian marls of England as reputed to possess a very special action, which is far from being explained.

Wheeler,§ in two successive years, grew mangels upon the light, acid soil of Rhode Island, to which, in addition to equal annual dressings with relatively abundant quantities of nitrate of soda and dissolved bone-black, several neutralizing agents were added together with potash salts. The pots 1 and 2 received carbonate of potash only—in 1894, 5.84 grms.; in 1895, 7.7 grms. Pots 3 to 10 received muriate of potash—in 1894, 7.36 grms. each; in 1895, 10 grms. The other distinctive characters of treatment, together with the weights of air-dried roots harvested, are shown below:

Number.	Pots.	Alkali added.		Yield.	
		1894.	1895.	1894.	1895.
		Grammes.	Grammes.	Grammes.	Grammes.
1.	Carbonate of potash only,			53.6	44.0
2.	Carbonate of potash only,			67.1	58.0
	Muriate of Potash Pots.				
3.	Caustic magnesia,	3.51	3.51	89.9	109.1
4.	Caustic magnesia,	7.63	7.63	120.0	128.3
5.	Carbonate of soda,	8.3	8.3	123.4	121.5
6.	Carbonate of soda,	16.6	16.6	133.5	131.2
7.	No alkali,			91.7	51.2
8.	No alkali,			89.7	91.3
9.	Air-slaked lime,	91.96	13.4	144.2	148.3
10.	Air-slaked lime,	91.96	13.4	126.8	122.0

*Oz. p. 66.

†American Fertilizer, G, 345.

‡Op. cit., 512.

§Op. cit., 206.

The conditions of moisture and food supply were such as to make the chief variable almost certainly the different neutralizing power of the several alkaline substances. The caustic magnesia is seen to have been almost as efficient as its chemical equivalent of carbonate of soda, and to fall not far below a very much larger quantity of air-slaked lime.

Upon acid soils, therefore, dressings of magnesian lime, if not made excessive in quantity, will be as effectual, if not more effectual than those of equal weights of purer limes.

REACTION OF SOILS EXPERIMENTED UPON.

In discussing the state of combination of the lime and magnesia contained in the soils experimented upon, it was assumed* that all the carbonic acid removed from the original soils by the action of a current of carbonic acid-free air and of warm hydrochloric acid, had been present in the soil in the form of calcium carbonate. It might be inferred that since each soil yielded some carbonic acid under this treatment, all must contain calcium carbonate and, hence, none could be acid in reaction. The inference is not strictly warranted because some of the carbonic acid may have formed in the air of the soil from the oxidation of organic matter, though the conditions were not favorable to any active oxidation; it is notable that while the combined percentages of lime and magnesia varied from 0.21 to 1.58 per cent., those of carbonic acid only ranged from 0.025 to 0.048 per cent. Another ground upon which the inference may be questioned is the authority of Stockhardt† and of Mondesir‡ for the belief that small quantities of calcium carbonate may remain undecomposed in a distinctly acid soil, possibly because of the large grain of its particles or because it is not uniformly distributed.

The water-soluble acidity was determined by Mr. Beistle in the aqueous extract made by washing 20 grammes of each soil, upon a funnel, with about 100 c. c. of distilled water and titrating with very weak (deci-normal) soda solution, using phenol-phthalein as an indicator. In all but four cases, only one drop of the alkali was sufficient to neutralize the acidity, but in these cases the quantities requisite were:

No.	Volume of alkali required.
5,	0.05 c. c.
6,	0.90 c. c.
8,	0.10 c. c.
9,	0.05 c. c.

*Cf. Table VI, p. 76.

†Jb. Ag. Chem., 1896, 10.

‡Ann. Sci. Agrcn., 1887, 2, 373-4.

Such a test, however perfectly it might be performed, would not suffice to show any acid constituents that are insoluble in water.

Mr. C. W. Norris applied the litmus test, using a very sensitive paper; all the soils showed some acidity, but it was decided only in cases of Nos. 5, 6, 8 and 9. A repetition some days later gave the same results. The very faint acidity is, of course, not indicative of a condition prejudicial to plant life, as has already been remarked.

The ammonia test was also applied by Mr. Norris by shaking 150 grammes (over four ounces) of the dry soil with distilled water to which a few drops of strong ammonia had been added, and noting any coloration evident a short time after the deposition of the sediment. The results were:

- | | |
|-------------------------|----------------------------|
| I. No coloration. | VI. Very deep brown color. |
| II. Light brown color. | VII. Light brown color. |
| III. No coloration. | VIII. Light brown color. |
| IV. No coloration. | IX. Light brown color. |
| V. Decided brown color. | |

Judging from the three tests, No. VI was strongly acid, No. V distinctly so, and Nos. VIII and IX slightly. A portion of the good results observed to follow liming on these soils must be attributed to their neutralization.

INFLUENCE OF LIME UPON THE ORGANIC MATTER OF SOILS.

The organic matter of the soil is for the most part the partially oxidized residue from pre-existing vegetation; the composition must be, in a measure, dependent upon the kind and proportion of the ash constituents, nitrogenous bodies and woody and other carbohydrate matters of which the plants were composed, as well as upon the conditions of their decay.

ULTIMATE COMPOSITION OF HUMUS.

This decay is accompanied by a liberation of carbonic acid, but if we may judge from the composition of the ulmic and humic acids formed artificially from sugar, the loss of carbon is less than of the other elements, for of dextrose it constitutes 40 per cent.; of humic acid, 64 per cent., and of ulmic acid, 67.1 per cent., according to Mulder.* It may be that the large proportion of carbon found in

*Cf. Johnson, *How Crops Feed*, 228-7.

humus is in part due to the more complete destruction of the readily fermentable substances, such as sugar, starch, etc., leaving in the residue a larger proportion of those modified celluloses—lignin bodies, hemi celluloses, cutose, etc.—which are richer in carbon than the more common and more fermentable carbohydrates. Thus, Fremy, treating wood with alkaline carbonates, extracted a group of substances separable from the extract by its acidulation. This precipitate he supposed to be one substance, with a content of 59.3 per cent. of carbon, which he termed *vasculose*. It is more readily obtained from straw than from wood.

SELECTIVE FERMENTATIONS DUE TO LIVING ORGANISMS.

Such a selective destruction occurs in the plant itself, when deprived of its leaf food and has been observed in the curing tobacco leaf* and in the decay of sweet fruits. In all these cases, either the living plant itself or a lower organism is the effective agent in producing the bio-chemical changes observed.

The presence in the soil of numerous lower organisms, moulds or bacteria, is so thoroughly established in numerous investigations that it is sufficient here to simply affirm the fact.

FERMENTATION OF STABLE MANURE.

The studies of Reiset,† Hebert,‡ Guyon,§ Schloesing || and Dehérain** upon the changes which the straw forming the litter of stable manure undergoes during the fermentation of the manure, are highly suggestive in this connection. In brief, they found that the sugar and closely related substances of the straw are destroyed by a ferment acting in the presence of air to form carbonic acid and liberate free nitrogen, while the cellulose is destroyed by another ferment, stirred to activity whenever air is admitted, but continuing to act in its absence, which liberates some carbonic acid and more marsh gas. There is left the “vasculose” in a modified condition, partially dissolved in the alkaline liquids of the fermented manure. Upon the evaporation of this solution, a shining black substance is left containing about 40 per cent. of ash, 36 per cent. of vasculose and 24 per cent. of nitrogenous substances. The ash contains, strange to consider, phosphoric acid, lime and ferric oxid; in the absence of the organic materials these phosphates could not exist together in a neutral or alkaline liquid. The nitrogenous material too, while its

*Of. Rep. Penna. State College, 1894, p. 190. seq.

†Of. Dehérain, *Traité*, 683.

‡Ann. Agron., 16, 353.

§Comptes rendus, 98, 528.

||Comptes rendus, 106, 529; 109, 336; Ann. Agron. 18, 5.

**Op. cit., 678 seq.

proportion can be diminished by repeated resolution and reprecipitation* can never be wholly dissociated.

FERMENTATIONS OF VARIOUS SOILS DIFFER.

The nature of the changes which vegetable matters undergo by the activity of the various soil ferments has not, at least so far as the non-nitrogenous constituents are concerned, been so closely worked out as have those to which the litter of stable manure is subject. There is much reason to believe that the reaction of the soil, and possibly other conditions, exercises a very decisive influence over the kind and rate of the changes occurring within its pores. It may be true of the soil humus, as Schloesing finds it to be of stable manure—which differed from clean litter in this respect—that change is not wholly prevented when the activity of the ferment organisms is precluded, so that it may be regarded as due in part to direct chemical action; but it is more probable that the principal agents by which fresh vegetable matter is converted into humus are fermentative or biological. The latter view leads to the expectation of dissimilarities in decomposition governed not only by climatic conditions and soil composition, but possibly also, by differences in the nature of the ferments present in different soils.

With this view of the agencies by which humus is formed, it is interesting to observe that the humus of different soils shows great variation in its solubilities, its power to support certain types of vegetation, the bacterial life present in it and the proportions of nitrogen and mineral matters closely associated with it.

GRANDEAU'S MATIERE NOIRE.

Upon treating soils with an alkaline liquid, after a previous treatment with an acid for the removal of readily soluble basic materials, Grandeau was able to extract a portion of the humus which, upon evaporation of the solution, shows an appearance similar to the black matter extracted from stable manure by alkaline solutions; and, like the latter, this black matter of the soil—*matiere noire*, as chemists continue to call it—contains ash ingredients that do not show their presence under ordinary tests until the organic substance is destroyed by ignition, or until subjected to dialysis, which enables them to pass through a membrane that holds back the organic substance. As in the case of the stable manure, not only silica and potash, but the ordinarily incompatible substances, phosphoric acid, lime and ferric oxid are found in the associated mineral matter; while nitrogen, too, is as closely associated as in the similar manure extract.

**Cf. Ann. Agron., 14, 116.*

ITS RELATIONS TO FERTILITY.

Grandeau contends that the *matiere noire*, which is particularly abundant in *mild humus*, such as that of old garden soils, is an important solvent of the mineral matters useful as plant foods, and that the immediate fertility of a soil is in large measure determined by the amount of the mineral foods that are present in chemical combination with the *matiere noire*. This is still a debatable point, but there are many interesting facts affording some foundation for Grandeau's theory. He himself observed that the associated mineral substances in the *matiere noire* are more abundant in fertile than in sterile soil, and found them to vary from 2 to 60 per cent. of the entire extract.* Hilgard† found that in the extremely fertile "sugar-bowl delta" lands of the Brazos River, Texas, and in the bottom lands of the Colorado River of the West, in California, the entire amount of phosphoric acid is present in the *matiere noire*, while in poor lands a much smaller fraction of the entire phosphoric acid contained was present in such combination. Snyder,‡ in analysis of certain soils from the famous wheat lands of the Red River Valley, found that the wheat yield upon those soils seems to bear a closer relation to the amount of phosphoric acid contained in the *matiere noire* than to that of any other constituent, this element of fertility showing a rapid decrease under the exhaustive system of continuous wheat culture still largely practiced in that locality.

Dehérain§ goes further, and asserts that while wheat may do without it, a certain portion of the *matiere noire* is indispensable to the best growth of clover and other legumes.

POPULAR VIEWS AS TO THE INFLUENCE OF LIME UPON HUMUS.

With this view of the nature of humus we may turn to the influence of lime upon its amount and condition. It is generally admitted from practical experience that liming often promotes the rapid decomposition of green manures, sod and peat, with the formation of a very desirable humus, but that oft-repeated, heavy liming tends, on many soils, to a final depletion of the humus supply to such a point as to seriously affect their mechanical condition and general fertility. Thus, even the surface soil of moor lands|| is brought to such a low humus content that it is needful to turn up the humus-rich sub-soil in order to continue the cropping of the land.

EXACT INVESTIGATIONS UPON LOSS OF CARBON.

The exact investigations made upon loss of carbonaceous matter from humus soils show quite wide variations. The subject has

*Cf. Storer, I, 487.

†X Census, 5, 81.

‡Bulletin 53, Minn. Exp. Station.

§Ann. Agron. 9, 68; Traite, 523-4, 547.

||Cf. Heinrich, Mergel u. Mergeln, 30-31.

recently been quite elaborately discussed by E. Wollny,* after noting that dilute acids retard or prevent the decay of humus, that very dilute caustic alkali favors it, but strong solutions retard it, and that weak solutions of alkaline carbonates promote it especially, if the decay has already begun, he calls attention to the following results of investigation: E. Wolff† found that caustic lime added to fresh manure, which was then kept under cover, greatly diminished the loss, by decay, of both total organic matter and nitrogen. J. Nessler,‡ applying lime to turf and variously prepared bone-meals, found decay at first retarded, then increased, but with a total decrease from liming in the loss observed for a twelve-months' period. P. Petersen§ found the amount of carbonic acid given off from acid leaf mould greatly increased upon addition of calcium carbonate, the increase being far too great to be explained by any decomposition of the added carbonate. Wollny,|| himself, has made extensive investigations upon this subject. Addition of lime to artificial soils, the one containing as its humus material, rye straw, the other turf, found the evolution of carbonic acid diminished as the lime increased in the case of the rye straw, but increased in case of the turf. Other investigations in which turf, horse dung and humus from a sandy soil were used with different soil combinations, agreed in showing at first a decrease after liming (which is possibly due to absorption of the carbonic acid by the lime) followed by an increase, and later by a decrease; that is, while lime favors a rapid progress in the early stages of the fermentation, it has a later conservative influence.

RELATIONS OF LIME TO MATIERE NOIRE.

A number of investigators are of the opinion that lime is a conservator of the *matiere noire*. Dehérain** notes that lime salts precipitate most, but not all, of the *matiere noire* of stable manure from solution and notes that this explains the observation of P. Thenard that while the drainage waters of recently manured sandy soils are sometimes discolored, those from calcareous soils are not. Mulder†† had earlier observed a similar precipitation of humate of ammonia (equivalent in part to Grandeau's *matiere noire*) by caustic lime and magnesia, calcium and magnesium chlorids and by ferric, ferrous and manganic sulfates. Kostycheff,‡‡ studying the causes that have led to the production of the wonderfully fertile black soil of Russia, commonly termed *tchernosem*, believes that the coloration is due to

*Die Zersetzung d. organischen Stoffe, 123-134.

†Ldw. Vers. Stat., 1859, 141.

‡Ber. Arb. Grossh. Vers. St. Karlsruhe, 1870, 93-106.

§Ldw. Vers. St., 13, 155-175.

||Op cit. and J. f. Ldw., 1886, 261.

**Traite, 522.

††Chem. d. Ackerkrume, quoted by Johnson, How Crops Feed, 231.

‡‡Ann. Agron. 17, 17.

changes, in the presence of lime compounds, resulting in the formation of substances which, like the group of substances related to tannin, blacken by oxidation on exposure to the air. Hilgard* notes that lime brings about a more rapid transformation of vegetable matter into *active humus* (*matiero noire*), manifest in the deep black tint of the soil—a tint which is not present except when there is abundance of alkaline or alkaline earthy carbonate also present. He further affirms that lime protects the *matiere noire* from the oxidizing influences of a hot climate. On ordinary uplands, tending to a lime deficiency, he finds only 0.4 to 0.7 per cent. of *matiere noire*; in the more prominently calcareous soils, 1 to 1.5 per cent. or even more. He also considers that the lime materially influences the proportion of the phosphoric acid that is present in the *matiere noire*; while there are exceptions noted, as a general rule soils rich in lime contain most, and occasionally all, of their phosphoric acid in this combination, while soils poor in lime contain only one-fourth to one-tenth of their phosphoric acid in similar condition.

A. Bernard† observes that calcium carbonate unites with *matiere noire* to form a compound not soluble in ammonia until the lime be first removed by acid treatment.

On the other hand, Wollny‡ found a greater evolution of carbonic acid from a pure calcium humate than from acid humus, indicating that some, at least, of the materials present in the later stages of decomposition are not preserved from further decay by liming, but rather hastened therein. Kellner§ found an increased loss after liming both upland and paddy soil (the latter formed under conditions of submergence for part of the year), but much greater in the latter soil.

LIMING INCREASES RETENTIVENESS OF HUMUS.

It is quite generally agreed that the liming of humus tends to increase its power to fix potash and ammonia in soils where lime has previously been deficient.||

In our experiments a careful study was made of the amount of total organic matter and of active humus (*matiere noire*) in soils VI (muck) and VII (limestone clay) after treatment by fallowing, and by application of lime and magnesia respectively. The work upon these points was performed, upon portions of the treated soils used for the analyses previously reported, by Mr. M. S. McDowell, Assistant Chemist of the Experiment Station.

Van Bemmelen** having called attention to the fact that in the ordinary method of determining moisture by drying the soil at the

*X Census, 5, 77, 81; Bull. 3, U. S. Weather Bureau.

†Le Calcaire, 150.

‡Loc. cit.

§Bull. 9, College of Agriculture, Tokio, Japan; Exp. Sta. Record, 2, 703.

||Of. Storer, I, 406.

**Law., Vers. Stat.

temperature of boiling water, other volatile matters and water of crystallization and of combination in both mineral and organic matters might be driven off, an additional determination was made of the loss of water by the soil upon suspension in a cooled bottle (temperature 3 degrees to 15 degrees C.), over sulfuric acid until the weight of the sample no longer decreased.

In addition, determinations of the total loss upon ignition and of the *matiere noire* extractible by the Huston-Grandean* method were made. All determinations are based upon duplicate tests.

The results were as follows:

TABLE XII—Organic Matter in Air Dry Soils. (Per Cent.)

Determinations.	Muck VI.			Limestone Clay VII.		
	Fallow.	Lime.	Magnesia.	Fallow.	Lime.	Magnesia.
1. Moisture lost at 3°-15°C.	2.12	1.75	2.05	.36	.26	.27
2. Additional loss at 100°C.	2.94	2.85	2.63	.52	.57	.56
Total moisture (1+2),	(5.07)	(5.10)	(5.76)	(1.23)	(1.26)	(1.23)
3. Total loss by ignition,	21.23	21.75	22.22	5.36	5.23	5.49
Organic Matter.						
(3—Total moisture),	(15.76)	(16.65)	(16.46)	(4.08)	(4.12)	(4.26)
4. <i>Matiere noire</i> ,	8.17	7.49	7.66	2.50	1.44	1.63
Per cent. of organic matter present as " <i>matiere noire</i> ,"	(51.94)	(44.30)	(49.17)	(50.39)	(24.95)	(28.26)

*Corrected for carbonic acid lost by ignition, 26.68. †Similarly corrected, 2.22.

As to the moisture, these results seem to indicate that only a small part of the loss of weight from the air-dry soil when it is heated at the boiling point of water, is removable at the ordinary temperature in the manner previously described—the losses over sulfuric acid being, from the muck, one-third, and from the limestone clay only one-fourth of the entire loss. If it be true that the excess of loss at 100 degrees C. over that at ordinary temperature under these conditions, is due to loss of water of combination, these soils seem to have undergone a great deal of dehydration in the drying process. The subject merits an investigation with more complete checks.

It is not surprising to find the air-dry muck holding so much more water than No. VII, as that is the tendency of soils highly charged with organic materials.

The *total organic matter* has been estimated by subtracting from the percentage of loss occurring upon careful ignition, the *total moisture* lost at 100 degrees C. Admittedly this tends to give a figure too high. Not all the water of crystallization of minerals is given off at the temperature of boiling water, but the residue is expelled upon

*Proc. Assoc. Official Agr. Chem., 1895, 42.

ignition; again, complete ignition tends to dissociate any carbonates present in the soil, liberating the carbonic acid. But the amount of carbonic acid in the original material of these soils amounted to only 0.04 per cent. (*circa*), while that in the treated soils was as follows:

	No. VI.	No. VII.
Lime treatment,	0.023	0.202
Magnesia treatment,	0.080	0.068

So that, except in the case of the limed soil, VII, the correction for this loss would not be appreciable; but if it be assumed that all the carbonic acid was expelled in the ignition of the limed soil, No. VII, then the total organic matter will be more nearly 3.92 per cent., and the proportion of it present as *matiere noire* would be 36.63 per cent. There are no data by which a correction for the former of the two sources of error can be made.

The active humus in the original soils was earlier determined by Mr. W. S. Sweetser, then Assistant Chemist of the Experiment Station; calculated to their proportions in the water-free soil, the percentages of humus in the original and the fallow soils are:

	VI.	VII.
Original,	2.22	2.12
Fallow,	2.59	2.22

So that little change in this constituent appears to have resulted from the fallowing.

As for the preserving action of the two applications, it appears that in the muck soil there was less loss of total humus in the soils treated with lime and magnesia, but that there was a distinctly greater diminution of the *matiere noire*.

In the limestone clay soils, the figures for total organic matter agree too closely to warrant any distinction, but here, too, the amount of *matiere noire* was found considerably less in the soils receiving lime and magnesia. In both soils, the decrease of *matiere noire* was less with magnesia than with lime.

Under the conditions of our experiments, therefore, liming, or the application of magnesia in liberal dressings is found not to preserve but to destroy the active humus more rapidly than that which is less soluble.

EFFECT OF LIME UPON THE NITROGENOUS SUBSTANCES OF THE SOIL.

RELATIVE GAIN OF NITROGEN IN FORMATION OF HUMUS.

Kostytscheff,* in his studies of the formation of the black soils of Russia, to which reference has already been made, observed that nitrogen was lost during the decay of the plants from which the humus is, in this case, derived, much less rapidly than carbon, so that, while it amounted to only 1 to 2 per cent. of the plants, the humus contained 4 to 6 per cent.

Hilgard and Jaffa† found that this divergent tendency is magnified in arid regions as shown by the following figures:

	Number of samples.	Humus in soil.	Nitrogen in humus.	Humic nitrogen in the soil.
		Per cent.	Per cent.	Per cent.
Arid soils,	18	.75	15.87	.101
Semi-arid soils,	8	.89	10.08	.122
Humid soils,	8	3.04	5.24	.122

In extreme cases they found more than 6 per cent. of nitrogen, the average in pure albuminoids, in the humus of arid soils.

Dehérain‡ states, on the basis of analyses by Boussingault, Truchot and himself, that the ratio of nitrogen to carbon in various soils ranges, in arable lands (nitrogen being taken as the unit of comparison) from 4.8 to 45.0, and in prairie or grass lands from 6.8 to 20.0, the percentage of nitrogen in the soil varying in the arable lands from 0.046 to 1.05, and in the grass lands from 0.180 to 0.940.

CONDITION OF NITROGEN IN SOILS.

Way,§ in examining certain drainage waters, found from 2.78 to 21.05 parts of nitric acid in 100,000 parts of the water, and only from

*Ann. Agron., 17, 17.

†Agricultural Science (1894).

‡Traité, 292.

§Jour. Roy. Soc., 17, 123.

0.009 to 0.025 parts of ammonia. The nitric acid was more abundant than any single base.

It must not, however, be inferred from this that the soil ordinarily contains large quantities of soluble nitrogen compounds. On the contrary, the major portion is present in difficultly soluble form, despite the fact that in the leaves and stalks from which the humus is formed, much of it is present in soluble amid compounds, such as asparagin. Furthermore, the nitrogenous matter is not nearly as liable to putrefactive fermentation as are the albuminoids of plant and animal tissues.

The nitrogen of the soil has been found chiefly in three classes of compounds: in ammonium salts, in nitrates and in organic matter. But very little of it is commonly present in the first two classes of compounds. Boussingault,* for example, found in the garden soil of Liebfrauenberg, the following proportions of nitrogen in the various states of combination:

Total nitrogen,	0.261 per cent.
Ammonia,	0.0022 per cent.
Nitric acid,	0.00034 per cent.

That is, only 4 per cent. of the total nitrogen was present in the more soluble combinations. This soil, the investigator found, despite its richness in nitrogen, would not, when prevented from receiving the nitrogen compound that come in the rain, yield much more material to growing crops than the latter were able to obtain from barren soils.†

It appears then that plants must, for the most part, take their nitrogen from the soil, either in the form of ammonia or of nitric acid.

The beautiful research of Muntz‡ has shown that, in the entire absence of nitrates and of the conditions to which their formation is due, plants can take up the nitrogen they need directly from ammonium compounds.

But the great fertilizer value of the nitrates has been known since the sixteenth century, and they have been shown by the interesting researches of Berthelot and André§ to be present in all plants at some stage in their lives.

CAUSES OF FORMATION OF AMMONIA AND NITRIC ACID IN SOILS.

There was formerly much difficulty in accounting satisfactorily by rational chemical theories for the varying transformations of the inert nitrogenous substances into the ammonium compounds and

*Agronomie, I.

†Of. Johnson, How Crops Feed, 280-281.

‡Dehérain, Traité, 109-110.

§Ann. chem. phys. [6] 8, 75-128.

nitrates. It is now known that the formation of both classes of compounds is chiefly due to the action of living organisms (bacteria) upon the inert nitrogenous substance of the soil.

Our present knowledge upon these changes is due chiefly to the investigations of Berthelot and André,* Schloesing and Muntz,† Winogradsky‡ and Warington.§ There seem to be three classes of organisms concerned in the transformations:

1. An ammonical ferment changing organic nitrogen to ammonia.
2. A nitrous ferment, converting the ammonia to nitrates.
3. And possibly a nitric ferment accomplishing the oxidation of nitrites to nitrates.

Under proper conditions for nitrification, as the conversion to nitrates is termed, the ammonia is oxidized even more rapidly than it is formed from organic matter. The conditions for favorable action are: 1. Free circulation of air in the soil. Illustrative of this condition is the recent observation of Kellner and others|| that the liming of a dry soil to which ground fish had been added induced a rapid nitrification, while in the submerged soil of the "paddy" field, the fermentation stopped with the formation of ammonia. 2. A suitable degree of moisture. 3. The presence of the active ferment. 4. The presence of a base with which nitric acid may combine as it forms, since the fermentation ceases with the appearance of acidity. 5. A temperature ranging between 40 degrees and 113 degrees Fahr.

It has been observed that in undrained marsh lands and especially in forest soils that nitrates do not form. Frank notes the great development of moulds in the forest soil and that the trees are devoid of fine absorbent root-hairs, but have the growing portions of their root systems thoroughly penetrated by the thin hair-like hyphae of these moulds; he suggests, therefore, the probability that the moulds attack the inert organic matter and act as purveyors thereof to the trees.**

NATURE OF INERT NITROGENOUS COMPOUNDS.

There is much uncertainty as to the real state of combination of the inert nitrogen in the humus. Johnson,†† on the basis of the behavior of this nitrogen with alkaline earths, such as lime; of the fact that albuminoids, such as are present in the plant, commonly yield amides upon decomposition, and that the reversion of ammonia to inert forms, which sometimes takes place in the soil, is most readily explained by this hypothesis, suggests the probability that the combination is of an amid nature.

*Ann. chim. phys. [6], 11, 375.

†Cf. Dehérain, *Traité*, 403.

‡Ann. de l'Institut Pasteur, 4, 313.

§Cf. Dehérain, *Op. cit.*, 103.

||Bull. 9, College of Agr., Tohio, Japan; Exp. Sta. Rec., 2, 764.

**Cf. Also Storer, I, 417-419.

††How Crops Feed, 276-280.

INFLUENCE OF LIME ON SOIL AMMONIA.

Concerning the effect of lime upon the nitrogenous constituents of the soil: It is common laboratory experience that on the addition of caustic lime or carbonate of lime to solutions of ammonium salts, at ordinary temperatures, ammonia is liberated.

A. Bernard* finds, that upon application of ammonium sulfate to soils containing no more than 1 per cent. of lime, a liberation of ammonia occurs in from five to ten minutes.

It is probable that ammoniacal fermentation of the soil is promoted by the presence of calcium carbonate; but an excess of the caustic lime would tend to be injurious to the ferments. Ladureau† observed that the addition of lime to a 2 per cent. solution of urea retarded the action of the ammoniacal ferment in proportion to the amount of lime introduced.

LIME AFFECTS NITRIFICATION.

As to the influence of lime compounds on nitrification: Touvenalt‡ long since observed that the formation of nitre in nitre-beds is most favorably affected by the use of chalk and pure carbonate of lime. But quick-lime he found to be much less useful. Boussingault§ found that caustic lime caused a loss of ammonia from garden soil and a hindrance of nitrification. Indeed, an excess of it in the presence of moist earth may induce putrefaction and a consequent destruction of nitrates. Warington|| found that lime water was twice as strongly alkaline as is desirable for the best development of the nitric ferment. Very heavy limings have been observed to materially reduce the richness of vegetation of a soil for the first year, but to conduce to a rankness of growth thereafter, indicating that the lime had meanwhile been converted from the caustic into the carbonated form. Bernard, therefore, suggests that it is dangerous to apply caustic lime to an already calcareous soil, and Wollny** cites experiences of Pichard,†† Warington‡‡ and Dumont and Crochetelle§§ to the effect that where there is already a tendency to alkalinity, applications of sulfate of lime or of potash would be more helpful than even the corresponding carbonates.

On the other hand, Bernard|| notes that on non-calcareous soils, organic materials, even those so readily nitrifiable as dried blood, often fail to show markedly beneficial results and require, in the

*Le Calcaire, 66-75.

†C. R. 90, 887.

‡Of. Storer, I, 301.

§Storer, Loc. Cit.

||Ann. agron., 14, 49.

**Op. cit., 136.

††C. R. 89, 1269 114, 490.

‡‡Ann. agron., 14, 557.

§§C. R., 117, 670.

||Op. cit. 76-87.

absence of liming, direct applications of nitrates or ammonium salts to supply the requisite nitrogen. Muntz and Girard* observes that the distinctly acid soils of Brittany and also the non-calcareous soils of Limousin set up little nitrification in added fertilizers unless the latter can supply the requisite alkali.

Kellner has observed that magnesia affects nitrification favorably, but Winogradsky was led to prefer lime compounds instead of the magnesium salts he earlier used in his culture fluids for the nitrifying bacteria.

NITROGEN DETERMINATION IN SOILS.

The observations upon the changes which the nitrogen in the several soils experimented upon, underwent as the result of the several treatments, were confined to Nos. VI and VII.

In addition to the determinations of moisture, organic matter and active humus already discussed, there were determined:

1. Total nitrogen by the official Scovell-Kjeldahl method, working upon 2 g. of No. VI and 20 g. of No. VII.

2. Nitric and ammoniacal nitrogen combined, using the official Ulsch-Street method, working upon 20 g. of the soil.

3. Ammoniacal nitrogen: 20 grammes of the soil were distilled under reduced pressure with caustic magnesia; enough of the reagent was used to make the liquid distinctly alkaline, 5 g. being the usual amount. It is well known that the accuracy of the method is impaired by the tendency of amids, if present, to liberate their nitrogen in the form of ammonia, when brought into contact with alkaline earths, lime being more powerful than magnesia. It has been suggested that under reduced pressure, the latter reagent will not effect so extensive decomposition.

Under my direction, Mr. W. S. Sweetser distilled various amid substances at ordinary pressures and at a pressure so reduced that the boiling point of the liquid ranged from only 32 degrees to 38 degrees C. The amounts of ammonia found in the distillate are expressed in terms of their equivalent of decinormal ammonia solution (3.5 g. ammonium hydrate to the litre). O. P.—Ordinary pressure; V.—In vacuo:

TABLE XIII—Liberation of Ammonic from Organic Substances upon Distillation.

	Cubic centimeters of N-10 ammonia equivalent.
250 distilled water with 5 g. caustic magnesia,	0.1
.10 g. urea, in distilled water (O. P.),	1.8
.10 g. urea, in distilled water (V.),	1.7
.10 g. urea, in distilled water with 5 g. caustic magnesia (O. P.),	2.0

*Ann. agron., 17. 297.

Cubic centi-
meters of N-
16 ammonia
equivalent.

.10 g. urea, in distilled water with 5 g. caustic magnesia (V.),	0.4
.10 g. uric, acid, in distilled water with caustic magnesia (V.),	0.6
.20 g. asparagin, in distilled water (V.),	0.5

Some loss occurs even on boiling in pure water at reduced pressures; caustic magnesia did not appreciably increase this loss.

4. Humus nitrogen was separately determined in an aliquot portion of an extract prepared by the Huston-Grandeau method, except that 3 per cent. caustic soda instead of 4 per cent. ammonia water was used as the solvent; the Kjeldahl method of nitrogen determination was used.

5. There are present in the soil several types of amid bodies. Some of these, being acid amids, give up their ammonia when heated with a strong acid. To estimate the nitrogen in this state of combination, 100 g. of the soil was suspended in 500 c. c. of water, containing 15 g. of strong hydrochloric acid, and kept upon a water-bath for forty-eight hours. The total nitrogen in an aliquot of the carefully filtered liquid was determined and the amid nitrogen estimated by subtracting from the amount of nitrogen thus found, the sum of the nitric and ammoniacal nitrogen. It is not sure that all the acid-amid nitrogen is recoverable under these conditions, but is believed that most of it should be.

Attempts were also made to separate the nitrogen present in form of amido acids, if any, by treatment with nitrous acid; but thus far we have not succeeded in preparing a satisfactory working method for such materials. The determinations in the original soil were made by Mr. W. S. Sweetser; in the treated soils by Mr. M. S. McDowell. The results obtained are given in terms of the water-free soil.

TABLE XIV—Nitrogen in Original and Treated Soils. (Per Cent. of Water-Free Soil.)

Determination.	Muck. (No. VI.)				Limestones Clay. (No. VII.)			
	Original.	Fallow.	Lime.	Magnesia.	Original.	Fallow.	Lime.	Magnesia.
Loss by ignition (total organic matter), .....	.....	22.24	22.92	22.53	.....	5.44	5.46	5.56
Humus (matiere noire),	8.23	8.59	7.86	8.15	2.13	2.23	1.46	1.65
Total nitrogen, .....	.678	.613	.585	.597	.116	.130	.125	.119
Ammoniacal nitrogen, .....	.0134	.0653	.0002	.0042	.0027	.0024	.0013	.0010
Nitric nitrogen, .....	.0210	.0041	.0074	.0419	.0125	.0124	.0157	.0201
Amid nitrogen, .....	.2637	.2608	.2337	.2467	.0379	.0457	.0458	.0417
Other organic nitrogen, .....	.2679	.2543	.2596	.2612	.0639	.0676	.0612	.0632
Nitrogen in Humus.								
a. Per cent. of entire soil, .....	.4012	.3705	.3329	.3560	.0324	.0538	.0486	.0456
b. Per cent. of humus,	4.33	4.34	3.73	3.62	3.78	3.50	3.29	3.76
Proportion of Total Nitrogen in the Several Nitrogenous Compounds.								
Ammoniacal,	2.23	.86	.05	.71	2.29	1.89	1.06	.85
Nitric,	5.37	5.52	7.94	7.02	10.83	10.39	13.41	17.35
Amid,	46.00	47.59	43.62	41.30	32.76	36.94	36.79	29.23
Other organic compounds,	46.31	46.08	49.37	50.97	54.13	51.87	48.74	53.57
(Humus),	(89.47)	(89.00)	(49.20)	(49.28)	(71.10)	(43.97)	(33.08)	(38.46)

It is to be remembered that here, as in preceding cases, the results reported are averages of several closely agreeing determinations, and that the sub-sample representing the "original" soil probably differs more from those representing the results of the several treatments than do the latter from each other.

A direct comparison of the *original* and *fallow* soils is not possible, but some conclusions of value may be had from a comparison of the proportions in which the nitrogen is represented in the several classes of compounds in the two sets of samples.

In both the muck and limestone clay there is a smaller proportion to the total nitrogen present in ammoniacal combination. In the muck, there is a little more present in nitric compounds, but in the clay considerably less.

There is more nitrogen present in amid combination, whether by reason of a primary formation of ammonia and its subsequent fixation in that form, or by direct transformation of other nitrogenous organic compounds, it is, of course, not possible to judge.

More of the nitrogen than is represented in the amid compounds is found in the active humus. The proportion of the total nitrogen present in the active humus is less in the fallow soil than in the original untreated sample. Evidently the fermentative changes occurring during the fallowing have resulted in making the nitrogenous substances of the organic matter relatively less soluble in alkaline liquids. This retrogression is particularly observed in the cultivated limestone-clay soil.

Comparing more closely the figures for the fallow and soils receiving lime and magnesia respectively, these facts appear:

The total nitrogen in the soil is slightly diminished in the limed soils and those receiving magnesia; this may possibly be due to a loss from the ammoniacal compounds, which are less in their residual amount in both lots of soil representing the effects of these treatments than they are in the fallow samples.

The nitrates are more abundant, very considerably so, where the alkaline earths were applied. In the muck, the magnesian treatment showed less nitrates; in the limestone-clay, more nitrates than the lime treatment.

In both cases there was also a marked decrease in the nitrogen present in amid condition, far greater than the increase of nitrates can counter-balance; in other words, whether by reason of appropriation in the organism of the ferment present or by simple chemical change, the nitrogen appears to have reverted in part to an even less readily decomposable form than the amid compounds. This was particularly true of the muck soil.

In both cases, also, the "*matière noire*" contains more nitrogen

than is accounted for by the amid compounds simply. The data afford no information by which we may judge whether the amids are entirely extracted in the "matiere noire" or not. If they are, the residual nitreous organic substances may be further sub-divided into two groups: That portion soluble as "matiere noire," and that part insoluble in the alkaline solvent.

It is observable, further, that the "matiere noire" from the limed soils is slightly richer in nitrogen than that from the magnesian treatment.

In general, the effect of both alkaline earths was to diminish the active humus, and the nitrogen, particularly that present as ammonia, and to increase the nitrates. While lime acted somewhat more vigorously than magnesia in the two particulars first named, there is no certain indication as to which was the more potent in favorably influencing the process of nitrification.

EFFECT OF LIMING UPON THE CHARACTER OF THE VEGETATION GROWING UPON THE TREATED SOIL.

It has been a matter of almost universal remark in localities where liming is practised, that its use is followed by a very marked change in the character of the vegetation, particularly in the quality and kind of cultivated crops and forage plants that the soil produces.

CLOVERS, GRASSES AND SORRELS.

The reports of correspondents from various portions of this State remark upon the greatly improved growth of forage plants, including the valuable grasses, but especially white and red clovers, after the application of lime; also, upon the disappearance of horse sorrel (red top," as it is called in some localities of the State) and of wild blackberries and dewberries.

Heinrich* notes the marked differentiation of the plants upon the same soil, on tracts that have been limed as compared with tracts not limed. He says: "In trials made upon a soil deficient in lime, one portion of which was limed, while another received a dressing of nitrate of soda, both receiving equal quantities of mixed clover and grass seed, the appearance was as though one part (that which was limed) had been seeded only with clover, the other only with grasses.

*Mergel u. Mergeln, &

Closer examination showed that both kinds of plants were present in each case, but that the plant most affected by the particular fertilizing material used, in each case, crowded out the other plants. To secure a mixed forage it is, therefore, not enough to seed with a proper seed mixture, it is needful to see that the chemical composition of the soil is such as is adapted to the several plants."

Flagg, Wheeler and Tucker* separated the several portions of the hay cut from plats that had received different treatments, and that were laid out upon the upland, granitic sandy soil of the Rhode Island Station upon which sorrel grows luxuriantly; they obtained the following portions by weight from areas two feet square:

Treatment.	Clover.	Sorrel.	Timothy.	Miscellaneous weeds.
	Lbs.	Lbs.	Lbs.	Lbs.
No nitrogen—limed,	2.28	0.06	0.00	Trace.
No nitrogen—unlimed,	0.00	1.25	Trace.	0.06
Dried blood—limed,	2.00	1.00	0.09	0.00
Dried blood—unlimed,	Trace.	0.95	0.00	0.05
Nitrate of soda—unlimed,	Trace.	0.70	Trace.	0.00
Sulfate of ammonia—unlimed,	0.00	2.50	0.00	Trace.

The almost entire absence of timothy in all cases is rather surprising, but the good effect of liming upon the clover yield is well shown. The authors says: "It appears probable that the chief value of lime in eradicating sorrel is attributable to the fact that it brings about physical and chemical soil conditions, one or the other or both of which, are so highly favorable to the growth of clover and many other agricultural plants that they are able to occupy the land, thereby preventing sorrel from gaining a foothold."

The writer has frequently observed a very striking growth of sorrel upon patches of land, the clover and timothy upon which have failed to make a catch, though in other seasons the same land shows very little sorrel, the season having favored a good stand of the grass seed.

Careful surveys of the several plats used in the rotation fertilizer experiments of the Pennsylvania Experiment Station have repeatedly shown the same phenomenon, and have further shown the predominance of clover over timothy on the plats receiving lime, ground limestone or land plaster as compared with those dressed with acidu-

*Rep. R. I. Agr. Exp. Sta., 1895, 198-199.

lated phosphates and nitrogen, the timothy predominating, however, on the latter.

Voelcker* says: "Every (British) farmer knows how essential lime is for the healthy growth of very kind of produce. On soils destitute of lime, most crops, and especially green crops, are subject to disease, and "root crops" are apt to fail altogether on such land, even if it has been liberally manured with dung or guano. Up to a certain stage, grain and roots grown under such conditions appear to thrive well, but as the season advances they sustain a check, and at harvest time yield a miserable return. The cure for such failures, which are not uncommon where poor sandy soils prevail, is a good dose of lime or marl, and then, and only then, dung or guano may be applied to the greatest advantage. The most liberal application of farm-yard manure of the best quality never produces so beneficial and lasting an effect on poor sandy soils as when they have been previously well marled or limed."

P. Pichard,† in reference to the sandy soils of Brittany which are rich in humus but poor in lime and potash, says: "The application of lime raised the yield of fodder beets from 6,315 kilograms to 21,627 and 38,700 kilograms per hectare, or, in other words, the yield was quadrupled and sextupled. An addition of plaster still further increased the yield."

Dehéraint‡ says: "There are certain of the principal field crops, notably the legumes, which are so highly benefitted by the presence of lime that liming alone on grass lands, where calcareous matter is deficient, is all that is needful to secure a spontaneous growth of clover, the seeds brought there by the wind prospering as soon as the soil is made favorable to it."

"Limousin had been for ages a miserable land, and it was not transformed nor brought to the state of relative prosperity which it now enjoys until the time when the construction of a railroad allowed the introduction, at low cost, of lime from the Département du Cher; the culture of clover, unknown until now in this granitic country, has become possible, more numerous and better fed domestic animals now supply enough manure to convert the thin pastures into productive grass lands; the food for an excellent race of Limousin beef being assured, its breeding has made rapid progress and the sale of the young animals has become a source of large profit to both land owners and tenants."

"In moist grass lands the use of lime has a remarkable effect; I have more than doubled the yield from the grass lands of l'Avre, belonging to the city of Paris, by treating them with lime or plaster, in addition to a small quantity of nitrate of soda."

*Quoted by Storer, II, 147.

†C. R., 119, 473.

‡Traité, 531.

Heinrich* says: "Potatoes and rye grow well even when the soil is too poor in lime for other crops. Large yields may still be obtained from soils, particularly when they are well cultivated, even though their lime content has fallen to 0.05 per cent."

"Oats and barley have a somewhat higher lime requirement than rye and potatoes."

"Peas and vetches grow quite well upon a soil having 0.10 per cent., but fail entirely upon poorer soil."

"Red clover yields well with 0.1 to 0.12 per cent.; with less than 0.1 per cent., it fails completely, and yields best when the soil contains at least 0.2 per cent. of lime."

"Of all crops, alfalfa responds best to lime."

On the other hand, he says:† "Lime as calcium carbonate injuriously affects the growth of lupins when it is present to the amount of 0.46 per cent."

Wheeler and Tucker‡ have conducted, for several years, comparative tests of the growth of a great variety of plants upon soils receiving each year a basal mixture of dissolved bone-black, muriate of potash and nitrate of soda, and, in 1895 and 1896, 200 lbs. per acre of sulfate of magnesia; part receiving no lime, the rest 5,400 lbs. per acre in 1893, 1,000 lbs. per acre in 1894, none in 1895. The relative yields from the limed soil for the several years are given below, the corresponding yield on the unlimed soil being taken as 1:

Yields of Various Plants after Liming.

	1893.	1894.	1895.	1896
Grasses.				
Awnless Brome Grass,			1.55	1.21
Kentucky Blue Grass,			1.20	1.21
Meadow Fox-tail,			1.30	
Meadow Oat Grass,			1.09	1.16
Orchard Grass,			1.16	
Red Top,			1.17	0.94
Rhode Island Bent,			0.99	1.13
Sheep's Fescue,			0.00	1.51
Soft Grass,			1.01	1.17
Sweet Vernal,			0.89	
Tall Fescue,			1.24	
Timothy,				1.22
Leguminous Forage Crops.				
Alfalfa (1st crop),			2.63	
Alfalfa (2d crop),			1.49	
Bean, Soja,		1.06		
Bean, White Podded Adzuki,	0.82	0.88		
Blue Lupine,	0.47	0.28	0.61	0.77
Cow Pea,	0.80	0.94		
Clover, Crimson,	1.35			1.59
Clover, Red,		1.70		
Serradilla,			0.69	
Millets.				
Panicum cruss-galli,	1.31		0.82	
Golden,	1.04	0.87		
Hungarian,	0.91			
Italian,	0.81			
German,		0.90		

*Mergel u. Mergeln, 7.

†Op. cit., 63.

‡R. I. Agrl. Exp. Sta., Bulletin 46, pp. 97-100.

Yields of Various Plants after Liming—Continued.

	1892.	1894.	1895.	1896
Grains.				
Barley,	1.80	2.06	2.58	2.56
Buckwheat,	1.65	1.53		
Corn, Dent,	1.17			
Corn, White-capped,	0.71			
Corn, Pop,	1.56		1.08	
Corn, Sweet,	2.07	1.11	1.89	
Corn, Field,		0.61	1.06	
Oats,	1.26	1.09	1.07	
Rye, Spring,	1.13	1.08	0.75	1.38
Wheat, Spring,		1.40	1.91	
Vegetables.				
Bean, Common White,	0.94	0.88		
Bean, Golden Wax,		1.53		
Beet, French Sugar,	12.17	11.00		
Beet, Golden Tankard,	10.75			
Beet, Eclipse Table,	7.78	5.35	1.84	
Beet, Mangel, Long Red,	7.59	5.77		
Beet, Mangel, Globe,		8.21		
Beet, Mangel,			4.95	5.73
Brussels Sprouts,		1.57		
Cabbage, Late,	2.37	4.60	1.70	
Cabbage, Early,	1.28	1.24		
Carrot, Victoria,	1.78			
Carrot, Mastodon,	1.76			
Carrot, Long Orange,		0.87		
Carrot, Danvers,		0.74		
Carrot, White,		1.18		
Carrot,			1.96	6.67
Cauliflower,		3.70		
Celery,		9.42	27.60	
Cucumber,		3.02		
Dandelion,		1.08	1.74	2.83
Egg Plant,		3.75		
Gumbo,		11.88		
Kale,	1.51	1.15		
Kohl Rabi,		1.59	1.00	
Lettuce,	77.92	10.00		
Martynia,		2.84		
Muskmelon,		4.70	2.45	
Onion, Red,		9.00		
Onion, Yellow,		5.12		
Onion, Barletta,		7.88		
Onion, Egyptian,		31.00		
Parasop,		6.99		
Pea, Garden,	1.53			
Peanut,		1.65		
Pepper,		2.74		
Potato, Early Rose,	1.08	1.05		
Potato, Beauty of Hebron,		1.67		
Pumpkin,		0.55	5.88	
Radish, Long Scarlet,		1.37		
Radish, French Breakfast,		0.37		
Salsify,		9.50		
Spinach,	24.75	61.00		20.50
Tomato,	1.40	1.49		
Turnip, Ruta Baga,	1.58	1.46		
Turnip, Purple Top,		1.29		
Turnip, Early Red Top,		1.15		
Turnip, Flat,			1.34	
Watermelon,		0.64	0.55	
Miscellaneous Plants.				
Gladiolus,				0.87
Jerusalem Corn,	2.41			
Kaffir Corn,	3.40			
Rape,		1.97		
Sorghum,	10.59	2.99		
Sorrel,		0.36	0.82	
Sunflower,	1.09	1.42		
Tobacco,		4.53		

Almost without exception the grasses have shown benefit from liming; among the millets, in only two cases out of seven; among the grains, barley, buckwheat and wheat have shown much more benefit than corn (with a curious exception in the case of sweet corn), oats or rye; among the leguminous forage crops there is a very strange

contrast, already noted by Heinrich and others: while the clovers and alfalfa exhibit a very marked advantage from liming, the soja bean shows none and the blue lupine, serradella, cow pea and white podded adzuki bean show most marked injury. Among the vegetables there was a very general improvement, except in the case of the watermelon and of some specimens of pumpkin, carrot and radish; beets, celery, gumbo, lettuce, onions and spinach were most advantageously affected. Among miscellaneous plants, sorghum and tobacco were most favorably, horse sorrel and the gladiolus unfavorably affected.

Salfeld* and Wheeler† incline to the opinion that the injury to the lupine and other legumes is not direct, but rather upon the minute organisms forming the nodules on the roots of such plants.

INFLUENCE UPON INSECTS AND INJURIOUS FUNGI.

Concerning its influence on hurtful insects and fungi, Storer‡ says: "Slaked lime is regarded as a cure for some hurtful fungi. The liming of seed grain to destroy the fungus which causes 'rust,' or 'smut,' has long been usual. The use of lime upon turnips, as check to the finger-and-toe disease has been mentioned; and I can myself bear witness that I have grown exceptionally fair and smooth rutabagas during three consecutive years upon limed land at the Bussey Institution, though no farmer in the vicinity would venture to try to grow turnips year after year on any one field, because of their liability to the disease called 'club foot.' * * * It is not improbable * * * that some part of the good done by the lime may be due to the destruction of insects and their larvae, as well as earth-worms and worms of other kinds, and fungi of various sorts. Indeed, lime-water, lime and mixtures of lime and salt (or, better yet, of lime and muriate of potash) are often purposely used by gardeners for destroying slugs and worms; and there are good reasons for believing that lime might often be applied to the soil with advantage in farming practice also on this account."

The voluminous literature of the American Experiment Stations state many observations in confirmation of Storer's opinion, though lime cannot be regarded as an universally applicable remedy. The

*Die Boden Impfung, pp. 79-83.

†Bull. 46, R. I. Exp. Sta., 32.

‡Op. cit., II, 147-8.

lime absolutely favors the potato scab fungus, and potatoes grown on limed soil from scabby seed are usually very greatly roughened by the exceptionable growth of the scab under such conditions.

Does the lime act in the soil in the caustic or in the carbonated form?

LIME SUPPOSED TO ACT CHIEFLY AS CARBONATE.

There is considerable doubt upon the above question. Recognizing the general tendency of lime to take up carbonic acid promptly by the process of air-slaking and considering the fine sub-division of the slaked lime as it reaches the soil, and the facts that the air of the soil is commonly much richer in carbonic acid than is the general atmosphere and that the fermentative destruction to which the humus and other organic matters of the soil are increasingly subjected through the influence of the added lime, must temporarily tend to a still greater proportion of carbonic acid in the soil air, it is generally conceded that the lime must be carbonated almost immediately after it is spread and harrowed in.

Storer* says: "It is not to be supposed that, in the field, reactions due to the causticity of the lime can go on for any long period." He then gives reasons, similar to those of the preceding paragraph, for this belief. "The action of the carbonate of lime, when formed, will not differ essentially from that of marl, or powdered limestone."

Mayer† also makes a very similar statement.

INFLUENCE OF FINENESS OF CARBONATE.

R. Heinrich,‡ going upon the above theory, claims that the lime changes almost immediately after its application to the soil, to the carbonate; the greater effect of burnt lime, as compared with pulverized chalk, limestone and other lime carbonates, is supposed to be due not to its causticity, but to the finer sub-division of the carbonate which is formed from it. To show the influence of fineness upon the effective action of calcium carbonate, this investigator grew peas and alfalfa in a series of pots; the sandy soil used contained only 0.091 per cent. of lime; the pots in most of the series received a basal manure containing potash and phosphoric acid, and four sets received a further addition of finely pulverized Carrara marble, of different degrees of fineness, graded by sifting, the quantity added in each instance being equal to 0.5 per cent. of the weight of the soil. Letting the maximum yield be represented by 100, the several crop yields were relatively as follows:

*Op. cit., II, 151.

†Lehrb. Agr. Chem., II, 306.

‡Mergel u. Mergeln, 39.

Treatment.	Peas.	Alfafa.
Unfertilized,	54.2	0
Basal fertilizer alone,	47.1	0
Fertilizer and marble, grains 1.5 to 2 mm. diameter,	68.7	59.2
Fertilizer and marble, grains 1.0 to 1.5 mm. diameter,	80.1	78.5
Fertilizer and marble, grains 0.5 to 1.0 mm. diameter,	90.2	100.0
Fertilizer and marble, grains less than 0.5 mm. diameter,	100.0	100.0

In other words, the carbonate in grains of 0.06 to 0.08 inches diameter, was scarcely more than half as efficient as that of about half that diameter, the surface exposed to the action of solvents being four times greater in the latter case, assuming an equal distribution of the particles in each case.

A. Bernard* suggests that the efficiency of the lime compound depends not solely upon its nature and fineness of sub-division, but also upon the relation between its effective surface and that of other soil constituents present; thus clay, being more finely divided than sand, would more largely modify the action of the lime than would sand.

COMPARATIVE EFFECTS OF CAUSTIC AND CARBONATED LIME.

It is further asserted that in many ways the actions of the caustic lime and the carbonate are almost precisely alike.

Thus, to test their relative efficiency in liberating alkalies from a soil, Heinrich† exposed 200 grammes of soil and of mixtures of the soil with caustic lime and calcium carbonate in quantities equivalent to 0.5 per cent. of calcium oxid for each 100 parts of soil. Water to the amount of 750 c. c. was used, and where carbonic acid was employed it was led into the liquid, already mixed with the soil, for one hour at the beginning of the period of twenty-four hours, during which the solvent acted in each case. The results are expressed in the weight of alkaline sulfates found in the liquid for each 100 grammes of soil used:

Treatment.	Weight of alkaline sulfate. Grammes.
1. Pure water,	0.031
2. Pure water with carbonic acid,	0.033
3. Pure water with caustic lime,	0.048
4. Pure water with caustic lime and carbonic acid,	0.068
5. Pure water with carbonate of lime,	0.048
6. Pure water with carbonate of lime and carbonic acid,	0.060

*Le Calcaire, 59-62.

†Op. cit., 29.

That is, the caustic lime and the carbonate were of equal effectiveness under like conditions of action.

Dietrich* had, much earlier, made a similar investigation, exposing soils and pulverized rocks for three months to the action of distilled water with (1) caustic lime, (2) calcium carbonate, (3) calcium carbonate and carbonic acid. Two hundred grammes of the material, from which readily soluble matter had first been removed by repeated washing, were used with 150 c. c. of water; the lime used equalled 1 per cent. of the soil, the calcium carbonate 2 per cent. The carbonic acid was added to saturation and four times renewed during the experiment. The alkalies made soluble are expressed as chlorids, in grammes:

Material.	Caustic lime.	Calcium carbonate.	Calcium carbonate and carbonic acid.
	Grammes.	Grammes.	Grammes.
Basalt, freshly broken, moderately fine,	0.144	0.067	0.154
Porphyry,	0.009	Trace.	0.011
Loam rich in humus,	0.022	0.014	0.022
Loam rich in humus, burned,	0.024	0.029	0.026

In this experiment, the carbonate was markedly inferior, except in case of the burned loam; with the aid of carbonic acid, however, its action was equal to that of the caustic lime. There is no satisfactory information concerning the fineness of the carbonate, however, so that the inferior action of the latter may be due to its coarseness rather than to its chemical inactivity.

The sulfate is said to be more potent than caustic lime in converting anhydrous silicates to the more available forms.

It has already been observed that the mild carbonate of lime is readily attacked by humus acids, so that it serves well the purpose of correcting soil acidity; also, that it more favorably affects nitrification than does caustic lime; and, very possibly, the same may be true of the other bacterial actions constantly occurring in the soil. Furthermore, if, as some aver, the flocculating action of lime be really due to a solution of acid calcium carbonate, the carbonate should equally well promote the improvement of heavy clay soils.

To secure more direct testimony as to the eventual net result of the various reactions set up in the soil by the application of lime in the caustic or the carbonated condition, Henrich† carried on an ex-

*J. prak. Chem., 74, 12; Jb. Agr. Chem., 1, 34.

†Op. cit., 22.

periment, using the same soil and basal manure as were employed by him in the previously described experiment made to determine the influence of the fineness of the carbonate upon its efficiency. In addition to the basal manure, enough of the several calcareous compounds was added to furnish calcium oxid equivalent to 0.5 per cent. of the soil. The relative weight of peas and alfalfa secured are given below, 100 standing for the maximum:

Treatment.	Peas.	Alfafa.
1. No fertilizer,	47	9
2. Basal fertilizer,	41	9
3. Marly loam from Lupitz (contains 8.46 per cent. lime),	79	97
4. Commercial precipitated shells (contains 64.39 per cent lime), ...	100	73
5. Wiesenkalk (contains 32.14 per cent. lime), used in fresh, soft state,	96	100
6. Caustic lime, powder, prepared from marble,	98	79
7. Chalk lime (Lüneburg manure), (61 per cent. lime),	98	80
8. Coral chalk (54.9 per cent. lime in dry substance),	84	84
9. White Carrara marble,	88	87
10. Precipitated chalk from sugar factory, .....	.....	86

The carbonates were finely powdered and passed through a very fine sieve before application.

In both cases higher results were obtained from certain carbonates than from the caustic limes.

On the other hand, the caustic action of lime as a fungicide or vermicide, can not be performed by the carbonate. Laboratory experiments also indicate a far less vigorous direct chemical action by the carbonate than by the caustic compound in decomposing organic matters.

General experience, especially upon heavy soils, leads to a decided preference for the burnt lime. Loudon* says: "The effect of powdered limestones * * * as a manure * * * is so much inferior to that of burnt lime that they have long since been laid aside."

But this may be due solely to the fact that it is not practicable to secure by purely mechanical means so fine a state of sub-division as that which is attained by burning and slaking.

LIME IN MASS NOT COMPLETELY CARBONATED.

Reasoning by analogy from the rate at which lime air-slakes in the heap, it is almost necessary to assume that lime can not long remain caustic after it has been spread and worked into the soil in a finely divided state. It is true, though, that compact lumps or masses of calcium hydrate, once their surfaces are carbonated, change very slowly through their interior portions. Thus, Reid states that upon examining mortar used several centuries since in the construction of

*Encyclopedia of Agriculture, § 337.

certain European buildings, the interior portions of the mortar were found to exist, even yet, in an uncarbonated, caustic condition.

CONDITION OF LIME AND MAGNESIA IN TREATED SOILS.

To secure direct evidence upon the state of combination of the lime and magnesia at the end of the experiments made in our laboratory and to further examine into the allegation that magnesium lime may owe its sometimes injurious action to the slower rate of its carbonatation, a careful determination of the amounts of carbonic acid present in the soils treated with lime and magnesia was made by Mr. C. W. Norris, using the method previously used upon the original soils. The results were as follows:

TABLE XV—Percentage of Carbonic Acid in Treated Soils.

Soils.	Lime treatment.	Magnesia treatment.
I,	0.207	0.094
II,	0.163	0.046
III,	0.235	0.095
IV,	0.116	0.259
V,	0.110	0.020
VI,	0.589	0.080
VII,	0.202	0.068
VIII,	0.125	0.015
IX,	0.183	0.045

Using these percentages and those obtained for the original soils, and correcting for the differences in soil moisture, but neglecting, as inconsiderable, any changes in weight the soils might have undergone from other causes, the percentages of the added lime and magnesia that had become converted to carbonates by the end of the experiment are estimated to be as follows:

TABLE XVI—Percentage of Alkaline Earths Carbonated in the Soil.

Soils.	Lime Treatment.	Magnesia Treatment.
I,	48.8	15.1
II,	31.7	1.8
III,	50.9	15.3
IV,	18.2	56.9
V,	21.7	•
VI,	•	•
VII,	41.5	7.5
VIII,	28.8	•
IX,	21.5	•

In those cases marked with a star, less carbonic acid was found at the end than at the beginning of the experiment. After ten months in thorough admixture with soils more or less supplied with humus, less than half the lime had combined with carbonic acid, in all but one soil. In the muck soil there was no more carbonic acid than at the outstart.

Concerning the conditions of these experiments it may be remarked that the lime did not lie exposed upon the surface of the soil for any length of time, nor was the contact of the soil with carbonic acid from the air so complete as would be the case in an open field. On the other hand, however, the lime was very finely sub-divided and well distributed through soils in which there was considerable decay of humus during the progress of the experiment, such as is supposed to furnish carbonic acid in abundance.

The evidence favors the belief that the conversion of caustic lime to carbonate in the soil may be much less rapid than has been heretofore assumed. The evidence does not, however, show positively the state of combination in which the uncarbonated lime exists. Some of it is doubtless affiliated with the silicates, humates or ulimates, nitrates and phosphates of the soil, but considering the relatively large quantity applied, it is difficult to conceive that a very large fraction has not remained in caustic condition.

MAGNESIA LESS READILY CARBONATED.

As for the magnesia, it evidently carbonates much less readily than the lime, and the inference that the evil effects sometimes observed after its application in magnesian limes, may be due to its persistent causticity, is strongly supported.

SUMMARY OF RESULTS OF THE PENNSYLVANIA EXPERIMENTS.

1. Most of the soils contained a moderate amount of lime, only two being strikingly deficient.
2. All but one contained more magnesia than lime.
3. No effect upon the moisture relations followed the use of lime. Very probably the failure to discover such effect is due to a faulty preparation of the soil for observation.
4. Liming was, in all cases, followed by increased availability of the potash, sometimes to nearly 50 per cent. of the original amount available.
5. A similar increase in available phosphoric acid occurred in all but one soil.
6. In four of the soils acidity was evident, so that some of the

benefit derived in practice from liming these soils is attributable to the neutralization of the acid.

7. There was less loss of total organic matter, but more loss of active humus as the result of liming compared with fallowing.

8. Liming resulted in a diminution of the nitrogen, from loss of ammonia in all probability; a marked increase in nitrates and, in one soil, of nitrogen in other organic compounds than the amids. The nitrogen in the form of amids, in one soil, and of active humus suffered a decided decrease.

9. At the end of ten months, much less than 50 per cent., on the average, of the added lime had turned to carbonate.

10. As for the magnesia, it liberated potash as freely as did lime, on the average; was even more influential than lime in its average effect in rendering the phosphoric acid more assimilable; an even smaller quantity would suffice of magnesia than of lime as a corrective of acidity; it affected total organic matter and *matiere noire* in manner and degree like lime, as also it did the various nitrogenous compounds, except that ammonia was more abundant in its presence. It carbonated very much less readily than lime.

So that, in general, its functions in the soil are very similar to those of lime. It is only when it is applied in large quantity so that it may keep the soil too highly alkaline for a long period or may, in some other manner, act poisonously upon the plant in the absence of a proper proportion of lime, that ground is given for objection to its use. Moderate applications of most of the magnesian limes of Pennsylvania can be made without fear when liming is indicated as desirable.

SOME FINAL PRACTICAL CONSIDERATIONS.

CIRCUMSTANCES SUGGESTING THE USE OF LIME.

It is not possible to indicate certainly all cases in which liming is admissible. Its use is clearly suggested as needful, sooner or later, upon light uplands whose characteristic vegetation shows that lime is not abundant. When soils are acid, whether from the oxidation of sulfids, from the residues of fertilizers or from humus; when clay soils become too adhesive; when swamp lands are to be brought rapidly into bearing (in both these last named cases, draining must precede liming to secure the full efficiency of the latter). It will be

helpful when heavy sod, a large green-manuring crop or a heavy dressing of very strawy manure is to be turned under, especially in a soil deficient in lime or magnesia; in these cases a good distribution of the lime in contact with the decaying vegetable matter should, in one way or another, be secured. When clover persistently fails, a moderate liming is suggested as a possible necessity before securing a good growth. It is clearly indicated on lands where turnips suffer from the "finger-and-toe" disease, but should be avoided where potatoes are to follow soon in the rotation. Where lime is cheap, it may prove, for a time, the cheapest means of securing available potash, by its action upon the unavailable supply already present in the soil. On soils relatively rich in iron and requiring the use of phosphatic fertilizers, a moderate dressing of lime before the time of fertilizing will greatly increase the duration of effect of the phosphate.

On the other hand, liming alone is insufficient on poor lands; they may respond well for a brief time, but are soon exhausted of the materials upon which lime can react. On such lands, heavy manuring must go hand in hand with liming. Indeed, even on lands of good heart, care must be taken to maintain the humus supply when liming is constantly practised.

FREQUENCY OF LIMING.

As to the frequency of liming, circumstances must somewhat determine. A single heavy dressing of lime may correct the undue plasticity of a clay and retain it in a flocculated condition for many years, particularly when it is tilled with judgment; later, light dressings applied at not too great interval, will suffice to retain the desirable texture indefinitely. For the correction of acidity a single heavy dressing may suffice for years. Where, however, the immediate breaking down of vegetable matter is desired, an application, at the time, of a properly adjusted quantity of lime would seem advisable.

QUANTITY TO BE APPLIED.

As to the quantity of lime applied: this must depend upon the frequency of the application, as well as upon the purpose sought to be accomplished. In correcting the plasticity of a heavy clay, or the acidity of a soil, or in preparing new land, rich in humus, for some intensive culture such as onion growing or celery, the first dressing may need to be heavy. An application of upwards of 100 bushels of slaked lime would doubtless prove economical in a few such cases. Good results have attended the use, in such circumstances, of as much as 500 bushels of slaked lime; but it is rare that better growth is observed where the lime was thickly spread, near the heap or wagon,

than where it lies more thinly upon the ground at the points more remote from the center of distribution. In general, it would be wise to prove by actual test that more than 100 bushels actually gives a paying result over and above that yielded by the smaller dressing, before going to the expense of the heavier application. As lime does not retain its maximum efficiency for a very long time, as it is among the substances more easily removed from the soil by drainage and, particularly, as it tends to pass quickly into the sub-soil while its effects are chiefly sought in the surface soil, lighter dressings at more frequent intervals are more likely to produce an economical result than very heavy dressings at longer intervals. Indeed, it may safely be stated as a rule applicable to most cases, that when the soil has already been brought into fair condition, an application of fifty bushels or even less will suffice to maintain heavy lands in good tilth and fertility if made once in six to ten years. On lighter soils, under like conditions otherwise, the dressing may often show its maximum benefit if no greater than twenty-five bushels. For light lands especially, is the maxim of very light dressings made more frequently, to be adopted. The dressing should be larger, the deeper the surface soil.

WHEN TO LIME.

For special purposes, the time for liming indicates itself—as in correcting some injurious condition of the soil, such as adhesiveness or acidity, or as in the preparation of new land for use, or as in the top dressing of a permanent meadow when clovers are failing.

But some plants, as Wheeler* has remarked, are especially liable to injury from the effect of caustic lime, and its use just before their planting is not commendable unless circumstances compel it; such crops are Indian corn, rye and millet. On the other hand, certain crops, such as beets, lettuce, spinach, celery, cauliflower, kohl rabi, onions, muskmelon, cantaloupes, salsify, cabbages, cucumbers, etc., seem to thrive especially well immediately after a liming. For the general purpose of maintaining in the soil an adequate supply of calcium carbonate, with all its attendant advantages and, at the same time, of gaining the maximum immediate advantage upon that crop in our general rotations that most fully responds to lime, it is believed that the use of a small quantity when seeding down or, in some ways even better, as a top dressing upon the clover in wheat or oats stubble, will give the largest return.

PREPARATION OF LIME.

The precautions that should be taken to keep the lime in a caustic state and to secure its proper slaking have already been stated with

*Bulletin 44, R. I. Agr. Exp. Sta., p. 94.

the reasons therefor. It only needs to be added that the lime should be worked thoroughly into the surface soil as soon as it is spread, except when it is to be plowed under with sod, green or stable manure, or when, of course, it is added as a top dressing to a growing crop.

METHOD OF APPLICATION.

When used before corn, it is commonly better to apply in the fall or winter, if spring plowing is adopted, and the plowing is shallow. In this way, the best return to the crop is often secured. If, however, the plowing is deep, better results have often attended the use of lime as a top dressing harrowed in some days before corn planting. There is some reason for believing that where the sod is very heavy, and is to be deep plowed, a division of the application, part upon the sod, and part, later, as a top dressing, would be more beneficial. The various means of distribution have been earlier discussed.

LIME SUBSTITUTES.

Where lime is not readily accessible, carbonate of lime is sometimes to be had in the form of leached wood ashes, tannery ashes or marl. The quantity to be applied must vary with the composition. It requires nearly twice as much carbonate as of pure, unslaked quicklime to perform a given work; often much more, from the fact that the ash, marl, etc., are much coarser grained.

Unleached wood ashes require some caution when used in large quantities. The considerable quantities of potassium carbonate they contain, often more than neutralize the flocculating effect of the calcium carbonate and leave a heavy soil even more adhesive and compact than before the application of the ash; but they are more efficient than lime in compacting very light soils.

APPENDIX A.

I.—LIST OF FARM CORRESPONDENTS—BY COUNTIES.

Adams,	Mr. L. W. Lighty, East Berlin. Mr. Geo. P. Myers, Flora Dale.
Armstrong,	Mr. S. S. Blyholder, Leechburg. Mr. A. M. Hindman, Craigsville.
Beaver,	Mr. Wm. T. Anderson, New Galilee.
Bedford,	Hon. J. S. Biddle, Loysburg. Mr. G. W. Oster, Osterburg. Mr. Thomas P. Beckley, Alum Bank.
Berks,	Hon. George D. Stitzel, Reading. Mr. J. W. Albright, Shartlesville.
Blair,	Mr. Frederick Jaekel, Hollidaysburg.
Bradford,	Mr. S. W. Lester, Troy. Mr. Asa S. Stevens, Franklindale.
Bucks,	Mr. John K. Scarborough, Pineville. Mr. Ezra Michener, Carversville. Mr. F. L. Mulford, Edgewood.
Butler,	Mr. Harlan Book, Euclid. Mr. O. W. Stoughton, Prospect.
Cambria,	Mr. David B. Wertz, Johnstown. Mr. John E. Tomlinson, Loretto.
Cameron,	Mr. E. M. Fairchild, Sizerville. Mr. B. V. Wykoff, Sinnemahoning.
Carbon,	Mr. George T. Wells, Rockport.
Centre,	Mr. T. M. Gramley, Spring Mills. Col. J. F. Weaver, Milesburg.
Chester,	Mr. R. M. Simmers, Phoenixville.
Clinton,	Mr. Joel A. Herr, Cedar Springs.
Columbia,	Mr. A. P. Young, Millville. Mr. Albert Cope, Berwick. Hon. William T. Creasy, Catawissa.
Crawford,	Mr. John C. McClintock, Meadville.
Cumberland,	Hon. S. M. Wherry, Shippensburg. Mr. B. D. Biggs, Shippensburg.
Dauphin,	Mr. S. F. Barber, Harrisburg. Mr. John Moyer, Gratz. Mr. Gabriel Hiester, Harrisburg.

Delaware,	Mr. Joseph H. Paschall, Ward. Mr. William M. Ott, Station M, Philadelphia.
Elk,	Mr. J. M. Wittman, St. Marys. Mr. Joseph Kaiser, St. Marys.
Erie,	Mr. H. H. Russell, Belle Valley. Hon. H. H. Chaffee, Lowville. Mr. B. J. Crowell, Lovell's Station.
Fayette,	Mr. W. E. Crawford, Belle Vernon.
Forest,	Mr. C. A. Randall, Tionesta. Mr. T. D. Collins, Nebraska.
Franklin,	Mr. Henry Omwake, Greencastle. Mr. C. B. Hege, Marion. Dr. A. H. Strickler, Waynesboro.
Fulton,	Mr. J. F. Johnston, Webster Mills. Hon. S. P. Wishart, Wells' Tannery.
Greene,	Mr. N. H. Biddle, Carmichaels.
Huntingdon,	Mr. George G. Hutchison, Warrior's Mark. Mr. T. O. Milliken, Cornpropst's Mills. Dr. W. T. Browning, Orbisonia.
Indiana,	Hon. N. Seanor, Denton. Hon. John Hill, Blairsville.
Jefferson,	Mr. James McCracken, Frostburg. Mr. John H. Lewis, Frostburg.
Juniata,	Mr. J. T. Ailman, Thompsontown. Mr. D. B. McWilliams, Walnut.
Lackawanna,	Mr. J. H. Hathrill, Moscow.
Lancaster,	Capt. J. P. Bricker, Lititz. Mr. James Collins, Quarryville.
Lawrence,	Mr. George Dean, Princeton. Mr. Thomas Love, Hillsville.
Lebanon,	Mr. Samuel Groh, Lickdale.
Lehigh,	Mr. Alfred J. S. Diefenderfer, South White Hall. Mr. P. P. Mohr, Fogelsville.
Luzerne,	Mr. John R. Gould, Bell Bend. Mr. William J. Honeywell, Dallas. Mr. H. B. Larned, Huntingdon Mills.
Lycoming,	Mr. Abner Fague, Picture Rocks. Mr. R. H. Grier, Jersey Shore. Hon. A. J. Kahler, Hughesville.
McKean,	Mr. Eugene Mullin, Bradford. Dr. A. B. Armstrong, Smethport. Mr. T. M. McClellan, Mt. Jewett.
Mercer,	Mr. J. C. Mossford, Millbrook.
Mifflin,	Mr. R. A. Naginey, Milroy.

Monroe,	Mr. Emil Ulrich, Stroudsburg. Mr. Randall Bisbing, Minsi. Hon. R. F. Schwarz, Analomink.
Montgomery,	Hon. Jason Sexton, Spring House.
Northampton,	Hon. B. B. McClure, Bath. Mr. W. M. Benniger, Walnutport. Mr. Albin F. Meyer, Moorestown.
Northumberland, ..	Mr. C. N. Marsh, Pottsgrove. Mr. B. F. Reitz, Elysburg.
Perry,	Mr. C. L. Steele, Duncannon. Mr. George S. Barnett, New Bloomfield. Mr. James E. Stephens, Acker.
Philadelphia,	Mr. J. B. Kirkbride, Bustleton.
Pike,	Mr. J. H. VanEtten, Milford.
Potter,	Mr. W. A. Gardner, Andrews' Settlement. Mr. John McDowell, Pleasant Valley.
Schuylkill,	Mr. W. H. Stout, Pine Grove. Mr. W. H. Riland, Friedensburg.
Snyder,	Mr. M. K. Hassinger, Middleburg. Mr. Jacob H. Hetrick, Beavertown.
Somerset,	Hon. N. B. Critchfield, Critchfield. Mr. C. S. Beal, Elklick.
Susquehanna,	Mr. E. W. Watson, New Milford.
Tioga,	Mr. F. E. Field, Balsam. Mr. Homer Wilson, Mansfield. Mr. W. W. Inscho, Canoe Camp. Mr. William Norman, Sebring.
Union,	Mr. R. J. Moyer, White Deer. Mr. H. G. McCarty, Spring Garden. Mr. John A. Gundy, Lewisburg.
Venango,	Mr. Porter Phipps, Kennerdell.
Warren,	Mr. R. J. Weld, Sugar Grove. Mr. J. P. Samuelson, Chandler's Valley.
Washington,	Mr. J. G. Berry, Primrose. Mr. J. B. Painter, Independence.
Wayne,	Mr. W. E. Perham, Niagara.
Westmoreland, ...	Mr. Geo. S. Barnhart, Greensburg. Mr. Daniel H. Pershing, Stauffer. Mr. John W. Welch, Bradenville.
Wyoming,	Mr. E. H. Pinder, Centremoreland. Mr. C. E. Henning, North Mehoopany.
York,	Mr. George F. Saubel, Brodbeck's. Hon. James A. Stahle, Emigsville.

II.—ADDRESSES OF LIME BURNERS AND DEALERS GIVING INFORMATION.

Berks,	Mr. M. G. Oberholtzer, Bechtelsville. J. S. Pearson & Co., Calcium. Dr. D. Heber Plank, Morgantown. Mr. Jacob Shaffner, Host.
Blair,	Keystone Lime and Stone Company, Tyrone. Mr. John Manning, Hollidaysburg. Mr. J. King McLanahan, Jr., Hollidaysburg.
Chester,	Avondale Lime and Stone Co., Avondale. Mr. Isaac Leshner, Williamson.
Jefferson,	Mr. Joseph M. Swisher, Punxsutawney.
Lancaster,	Mr. I. Galen Lefevre, Quarryville.
Lebanon,	Mr. John A. Bachman, Annville.
Lehigh,	Mr. A. W. Held, Fogelsville. Mr. E. D. Boyer, Catasauqua.
Lycoming,	Mr. Abraham Meyer, Cogan House. Mr. J. Sebring, Jersey Shore.
Monroe,	Mr. John P. Carmer, Bossardsville. Mr. Peter M. Heller, Bossardsville. Mr. Allen Metzger, Stormville.
Montgomery,	Mr. G. W. H. Corson, Plymouth Meeting. Todd & Son, Port Kennedy.
Northampton,	Mr. Edward Fehnel, Nazareth.
Northumberland, ..	Mr. A. C. Baylor, Milton.
Tioga,	Mr. D. F. Gates, Mansfield.
York,	Bittinger & Eberly, Hanover.
Sussex, N. J.,	Mr. George N. Cole, Montague.

APPENDIX B.

ANALYSES OF PENNSYLVANIA LIMESTONES.

COMPILED BY WILLIAM FREAR AND C. A. BROWNE, JR., FROM THE REPORT OF THE SECOND GEOLOGICAL SURVEY OF PENNSYLVANIA; THE CATALOGUE OF EXHIBITS OF THE DEPARTMENT OF MINES, WORLD'S FAIR COMMISSION OF THE STATE OF PENNSYLVANIA; AND THE RECORDS OF THE PENNSYLVANIA STATE COLLEGE AGRICULTURAL EXPERIMENT STATION.

SYMBOLS USED.

$\text{Al}_2 \text{O}_3$.—Alumina.
 Ca CO_3 .—Carbonate of lime.
 Fe .—Iron.
 Fe O .—Iron oxid.
 $\text{Fe}_2 \text{O}_3$.—Iron peroxid.
 $\text{Fe}_2 \text{CO}_3$.—Carbonate of iron.
 Fe S_2 .—Iron pyrites.
 $\text{H}_2 \text{O}$.—Water.
 Mg CO_3 .—Carbonate of magnesia.
 $\text{Mn}_2 \text{O}_3$.—Manganese oxid.
 Ca SO_4 .—Calcium sulfate.
 Si O_2 .—Silica.
 SO_3 .—Sulfuric acid.
 $\text{P}_2 \text{O}_5$.—Phosphoric acid.
 Mn CO_3 .—Carbonate of manganese.
 K_2O .—Potash.

Compilation number.	County.	Town.	Owner.	Geological Formation.	Remarks.
1.	Armstrong.	Putneyville.	Hamilton.	Freeport Upper limestone.	Dark gray, tough.
2.	Armstrong.	Logansport.	Mehaffey & McGill.	Freeport Upper limestone.	Pearl gray, brittle.
3.	Armstrong.	Logansport.	Mehaffey & McGill.	Freeport Upper limestone.	Pearl gray, tough.
4.	Armstrong.	Logansport.	Mehaffey & McGill.	Freeport Upper limestone.	Light pearl gray, hard.
5.	Armstrong.	Rural Village.	J. Riefer.	Freeport Upper limestone.	Dark gray, tough calcite.
6.	Armstrong.	Dayton.	Marshall.	Freeport Upper limestone.	Dark gray, tough.
7.	Armstrong.	Slate Lick.	Monroe.	Freeport Upper limestone.	Dark gray, tough.
8.	Armstrong.	Manorville.	Dull & Co.	Freeport Upper limestone.	Dark gray, compact.
9.	Armstrong.	Manorville.	Dull & Co.	Freeport Upper limestone.	Dark gray, calcite.
10.	Armstrong.	Manorville.	Dull & Co.	Freeport Upper limestone.	Pearl gray, calcite.
11.	Armstrong.	Cochran's Mills.	Putney.	Johnstown cement.	Bluish gray, tough.
12.	Armstrong.	Putneyville.	Putney.	Johnstown cement.	Bluish gray, hard, tough.
13.	Armstrong.	Madison township.	Stewardson Furnace.	Ferriferous limestone.	Pearl gray, contains fossil casts.
14.	Armstrong.	Madison township.	Stewardson Furnace.	Ferriferous limestone.	Pearl gray, contains fossil casts.
15.	Armstrong.	Mahoning Furnace.	Colwell.	Ferriferous limestone.	Bluish gray, contains fossil casts.
16.	Armstrong.	Kittanning.	Reynolds.	Ferriferous limestone.	Pearl gray, fossiliferous, calcite.
17.	Armstrong.	South Bend.	George.	Ferriferous limestone.	Dark gray, fossiliferous, calcite.
18.	Armstrong.	Greendale.	Rhea.	Ferriferous limestone.	Bluish gray fossiliferous, brittle.
19.	Armstrong.	Buffalo Mills.	Graf.	Ferriferous limestone.	Dark gray, brittle.
20.	Armstrong.	Kittanning.	Pine Creek Furnace.	Ferriferous limestone.	Bluish gray, compact.
21.	Blair.	Altoona.	Baker.	Lewistown limestone, Lower Heiderburg Form. No. VI.	Light bluish gray, fossiliferous upper layer.
22.	Blair.	Altoona.	Baker.	Lewistown limestone, Lower Heiderburg Form. No. VI.	Dark gray middle layer, contains calcite.
23.	Blair.	Altoona.	Baker.	Lewistown limestone, Lower Heiderburg Form. No. VI.	Gray lower layer, contains calcite.
24.	Blair.	Holidaysburg.	Creswell.	Lewistown limestone, Lower Heiderburg Form. No. VI.	Dark gray, hard, contains calcite.
25.	Blair.	Holidaysburg.	Manning & Lewis.	Lewistown limestone, Lower Heiderburg Form. No. VI.	Pearl gray, compact, contains calcite.

Blair,	Holldaysburg,	Loop,	Lawistown limestone, Lower Helderburg Form. No. VI,	Dark gray, hard, contains calcite Average supplied to Cambria Iron Co.
26. Blair,	Tyrone,	Keystone Lime and Stone Co., ..	.....
27. Blair,	Martinsburg,	John Manning, .....	.....
28. Blair,	Franktown,	J. K. McAnahan,	Limestone formation, No. VI, ..	Bluish gray, contains calcite.
29. Blair,	Franktown,	M. E. McAnahan,	Limestone Form. No. VI, ..	Dark blue, contains calcite.
30. Blair,	Catharine township,	M. E. Furnace,	Limestone Form. No. II, ..	Bluish gray, contains calcite.
31. Blair, .....	.....	Springsfield Furnace,	Limestone Form. No. II, ..	Bluish gray, contained calcite.
32. Blair, .....	.....	Redman Furnace,	Limestone Form. No. II, ..	Pearl gray,
33. Blair, .....	.....	Redman Furnace,	Limestone Form. No. II, ..	Light bluish gray, hard.
34. Blair,	Roaring Springs,	Redman Furnace,	Limestone Form. No. II, ..	Dark gray, hard.
35. Blair,	Tyrone, .....	.....	Limestone Form. No. II, ..	Bluish gray, hard, compact.
36. Blair,	Tyrone, .....	.....	Limestone Form. No. II, ..	Bluish gray, conglomerate-like.
37. Blair,	Birmingham,	Berie,	Limestone Form. No. II, ..	Bluish gray, conglomerate-like.
38. Blair,	Birmingham,	Keystone Zinc Co.,	Limestone Form. No. II, ..	"Burlington limestone," small fossil shells.
39. Blair,	Birmingham,	W. B. Kline,	Limestone Form. No. VIII, ..	
40. Bradford,	Burlington, .....	.....	Next to gneiss or primitive.	For lime.
41. Berks,	Morgantown,	D. H. Plank, .....	.....
42. Berks,	Bechtelsville,	M. G. Oberholzer, .....	.....
43. Berks,	Robesonia,	S. R. Deppan, .....	.....
44. Berks,	Caernarvon,	P. De Plank, D. Heber Plank, ..	Feriferous limestone	Reddish gray, brittle.
45. Berks,	Caernarvon,	P. De Plank, D. Heber Plank, ..	Feriferous limestone	Reddish gray, brittle.
46. Berks,	Caernarvon,	P. De Plank, D. Heber Plank, ..	Feriferous limestone	Reddish gray, brittle.
47. Beaver,	Caernarvon,	P. De Plank, D. Heber Plank, ..	Feriferous limestone	Reddish gray, brittle.
48. Beaver,	Vaupot township,	Soren,	Feriferous limestone	Reddish gray, brittle.
49. Beaver,	Vaupot township,	Power,	Feriferous limestone	Reddish gray, brittle.
50. Beaver,	Vaupot township,	Power,	Feriferous limestone	Reddish gray, brittle.
51. Beaver,	Vaupot township,	Tygart,	Feriferous limestone	Reddish gray, brittle.
52. Cumberland,	Pine Grove,	Pine Grove Furnace,	Siluro-Cambrian No. II, ..	Brownish gray, hard.
53. Cumberland,	Mt. Holly,	Craig Head,	Siluro-Cambrian No. II, ..	Dark bluish gray, soft, top of bed CXV.
54. Cumberland,	Harrisburg, .....	.....	Siluro-Cambrian,	Dark bluish gray, soft, bottom of bed CXV.
55. Cumberland,	Harrisburg, .....	.....	Siluro-Cambrian,	Dark gray, soft, compact, top of bed LXXXVI.
56. Cumberland,	Harrisburg, .....	.....	Siluro-Cambrian,	Dark gray, soft, compact, bottom of bed LXXXVI.
57. Cumberland,	Harrisburg, .....	.....	Siluro-Cambrian,	Dark gray, hard, compact, calcite, top of bed LXXXVII.
58. Cumberland,	Harrisburg, .....	.....	Siluro-Cambrian,	Dark gray, hard, compact, calcite, bottom of bed LXXXVII.
59. Cumberland,	Harrisburg, .....	.....	Siluro-Cambrian,	Light gray, hard, compact, calcite, top of bed XCVIII.
60. Cumberland,	Harrisburg, .....	.....	Siluro-Cambrian,	Light gray, hard, compact, bottom of bed XCVIII.
61. Cumberland,	Harrisburg, .....	.....	Siluro-Cambrian,	
62. Centre,	Oak Hall,	P. Dale, Dale, .....	.....
63. Centre,	Oak Hall,	P. Dale, Dale, .....	.....
64. Centre,	Oak Hall,	P. Dale, Dale, .....	.....
65. Centre,	Oak Hall,	P. Dale, Dale, .....	.....
66. Centre,	Boalsburg,	W. C. Myer, .....	.....

Compilation number.	County.	Town.	Owner.	Geological Formation.	Remarks.
67.	Centre.	Boalsburg.	W. C. Myer.	.....	Surface inch.
68.	Centre.	Bellefonte.	F. S. Rhoads.	.....	Dirty gray, siliceous.
69.	Centre.	Shoe Shoe Basin.	.....	.....	Very siliceous.
70.	Centre.	Bellefonte.	Shortlidge.	Siluro-Cambrian Form. No. II.	Hard compact, contains calcite, pearl gray.
71.	Centre.	Bellefonte.	Shortlidge.	Siluro-Cambrian Form. No. II.	Hard compact, contains calcite, pearl gray.
72.	Centre.	Bellefonte.	Shortlidge.	Siluro-Cambrian Form. No. II.	Hard compact, contains calcite, pearl gray.
73.	Centre.	Bellefonte.	Shortlidge.	Siluro-Cambrian Form. No. II.	Hard compact, contains calcite, pearl gray.
74.	Chester.	Avondale.	Avondale Lime and Stone Co.	.....	For building.
75.	Chester.	Barker Station.	Acme Lime Co.	.....	For building and fluxing.
76.	Chester.	Barker Station.	Acme Lime Co.	.....	Statuary marble.
77.	Chester.	Avondale.	Avondale Marble Co.	.....	Brownish gray, crumbling.
78.	Chester.	London Grove Twp.	Swayne.	Siluro-Cambrian Form. No. II.	Dark gray, calcite.
79.	Clarion.	New Athens, Madison Twp.	.....	Freeport Upper limestone.	.....
80.	Clarion.	Perry township.	Reichert.	Freeport Upper limestone.	Dark gray, calcite.
81.	Clarion.	Toby township.	.....	Freeport Upper limestone.	Bluish gray, hard.
82.	Clarion.	Porter township.	.....	Ferriferous limestone.	Pearl gray, brittle.
83.	Clarion.	Clarion township.	Hindman.	Ferriferous limestone.	Bluish gray, brittle, calcite.
84.	Clarion.	Clarion township.	Silgo Furnace.	Ferriferous limestone.	Bluish gray, tough.
85.	Clarion.	Clarion township.	Bargen.	Ferriferous limestone.	Bluish gray, calcite.
86.	Clarion.	Johnstown.	A. J. Hayes.	Cement bed.	Hard, brittle, contains pyrites.
87.	Cambria.	Glenn Hope.	.....	Siluro-Cambrian No. II.	Bluish gray, hard.
88.	Clinton.	Nippenose Valley.	J. Whisman.	.....	So-called "plaster."
89.	Crawford.	Harmonsburg, Summit township.	Whiting & Brown.	.....	A raw marl, covers 80 acres; used for lime and agriculture.
90.	Dauphin.	Harrisburg.	Rutherford.	Limestone Form No. II.	Dark bluish gray, East quarry.
91.	Dauphin.	Harrisburg.	Rutherford.	Limestone Form No. II.	Dark bluish gray, West quarry.
92.	Dauphin.	Harrisburg.	Couffer.	Limestone Form No. II.	.....
93.	Dauphin.	Harrisburg.	Frantz.	Limestone Form No. II.	.....
94.	Dauphin.	Harrisburg.	Crumbler.	Limestone Form No. II.	.....
95.	Dauphin.	Harrisburg.	Strickler.	Limestone Form No. II.	.....
96.	Dauphin.	Brandy Camp.	.....	Freeport Upper limestone.	.....
97.	Elk.	Horton twp.	J. S. Hyde.	.....	Bluish gray, brittle.

97.	Elk,	Brandy Camp, Horton tpw.,	J. S. Chamberlain,	Freeport Lower limestone,	Bluish gray, brittle.
98.	Elk,	Brandy Camp, Horton tpw.,	J. C. McAllister,	Freeport Lower limestone,	Pearl gray, brittle.
99.	Elk,	Wheat Run, Horton twp., Benesette,	A. R. Williams,	Freeport Lower limestone,	Bluish gray, brittle.
100.	Elk,	Benesette,	G. W. Williams,	Ferriferous limestone,	Pearl gray, brittle, calcite.
101.	Elk,	Benesette,	J. S. Chamberlain,	Ferriferous limestone,	Bluish gray, brittle.
102.	Elk,	Brandy Camp,	J. C. McAllister,	Ferriferous limestone,	Bluish gray, brittle.
103.	Elk,	Brandy Camp,	J. C. McAllister,	Johnstown cement bed, Benesette Middle limestone,	Bluish gray, hard and tough.
104.	Elk,	Brookport,	Oyster,	Ferriferous limestone,	Bluish black, shaly, fossiliferous, soft.
105.	Elk,	Brookport,	Oyster,	Ferriferous limestone,	Dark blue, brittle.
106.	Elk,	Brookport,	Oyster,	Ferriferous limestone,	Bluish black, shaly, fossiliferous.
107.	Elk,	Jones township,	Gen. Kane,	Ferriferous limestone,	Reddish gray, brittle.
108.	Elk,	Jones township,	Gen. Kane,	Ferriferous limestone,	Bluish gray, brittle, calcite.
109.	Elk,	Fox township,	Benesette,	Clermont limestone,	Bluish gray, brittle.
110.	Elk,	Benesette,	Benesette,	Benesette Upper limestone, Benesette Middle limestone,	Bluish gray, sandy fossiliferous.
111.	Elk,	Benesette,	Benesette,	Benesette Middle limestone,	Bluish gray, shaly, fossiliferous.
112.	Elk,	Caledonia,	Caledonia,	Benesette Middle limestone,	Bluish gray, crystalline, has pyrites.
113.	Elk,	Caledonia,	Caledonia,	Benesette Middle limestone,	Bluish gray, very sandy.
114.	Elk,	St. Mary's,	J. M. Wittman, Oliphant Furnace, Oliphant,	Sewickley limestone,	Blue, compact and contains pyrites.
115.	Fayette,	Georges township,	Oliphant Furnace, Oliphant,	Sewickley limestone,	Pyrites, brittle, contains cal- cite.
116.	Fayette,	Uniontown,	Lemont Furnace,	Redstone limestone,	Bluish gray, soft, brittle.
117.	Fayette,	Uniontown,	Lemont Furnace,	Pittsburgh limestone,	Bluish gray, hard, tough, sandy.
118.	Forest,	Tionesta,	Kelly,	Tionesta limestone,	Yellowish brown, soft.
119.	Franklin,	Mont Alto,	Mine No. 3 Iron Co.,	Tionesta limestone,	Light bluish gray, soft.
120.	Franklin,	Mont Alto,	Mine No. 4 Iron Co.,	Tionesta limestone,	A true lithological dolomite.
121.	Franklin,	Mont Alto,	Shiery,	Tionesta limestone,	Best quality from quarry.
122.	Franklin,	Williamson,	Hawbecker,	Tionesta limestone,	Worst quality from quarry.
123.	Franklin,	Williamson,	Hawbecker,	Tionesta limestone,	A cement quarry; now aban- doned.
124.	Franklin,	Scotland,	Battin,	Siluro-Cambrian No. II,	For fluxing and R. R. ballast.
125.	Huntingdon,	Union Furnace Station,	H. J. McAteer,	Siluro-Cambrian No. II,	
126.	Huntingdon,	Three Springs,	Hudson,	Lewistown limestone, Lower Helderberg Form. No. VI,	Compact, bluish gray, 70 feet above bottom of formation.
127.	Huntingdon,	Three Springs,	Hudson,	Lewistown limestone, Lower Helderberg Form. No. VI,	Compact bluish gray, 40 feet above bottom of formation.
128.	Huntingdon,	Three Springs,	Hudson,	Lewistown limestone, Lower Helderberg Form. No. VI,	Compact bluish gray, 50 feet above bottom of formation.
129.	Huntingdon,	Salttillo,	C. R. McCarthy,	Lewistown limestone, Lower Helderberg Form. No. VI,	Crystalline bluish gray, contains calcite.
130.	Huntingdon,	Salttillo,	C. R. McCarthy,	Lewistown limestone, Lower Helderberg Form. No. VI,	Siliceous, bluish gray.
131.	Huntingdon,	Salttillo,	C. R. McCarthy,	Lewistown limestone, Lower Helderberg Form. No. VI,	Water line cement beds, 375 feet above bottom of formation.

Compilation number.	County.	Town.	Owner.	Geological Formation.	Remarks.
122.	Huntingdon,	Saltillo,	.....	Lewistown limestone, Lower Heidelberg Form. No. VI, ...	Water line cement beds, 190 feet above bottom of formation.
123.	Huntingdon,	Saltillo,	.....	Lewistown limestone, Lower Heidelberg Form. No. VI, ...	Water line cement beds, 160 feet above bottom of formation.
124.	Huntingdon,	McAlevy's Fort,	Barr,	80+ ft. below fossil ore,	Bluish gray, dark, compact, contains calcite.
125.	Huntingdon,	Robertsdale,	.....	.....	Conglomerate of limestone and red shale.
126.	Huntingdon,	Broad Top City,	J. Diggins,	.....	Conglomerate of limestone and red shale.
127.	Huntingdon,	Todd township,	John Whitney,	Red Shale No. XI, Mauch Chunk,	Bluish gray, tough.
128.	Indiana,	West Lebanon,	A. H. Fulton,	Pittsburgh limestone,	Bluish gray, compact, brittle.
129.	Indiana,	Five Points,	Rev. S. Brown,	Freeport Upper limestone,	Bluish gray, compact, calcite.
130.	Indiana,	Chambersville,	Groff Brothers,	Freeport Upper limestone,	Dark bluish gray, compact.
131.	Indiana,	Jacksonville,	S. R. Rezielt,	Freeport Upper limestone,	Bluish gray, compact.
132.	Indiana,	Blairville,	D. R. Grifth,	Freeport Upper limestone,	Bluish gray, compact.
133.	Indiana,	Blairville,	G. Livingston,	Freeport Upper limestone,	Bluish gray, compact, calcite.
134.	Indiana,	Richmond,	Isaac Simpson,	Freeport Upper limestone,	Bluish gray, hard fossiliferous.
135.	Indiana,	Blairville,	Doyle,	Freeport Upper limestone, 120 ft. below Pittsburgh coal bed,	Bluish gray, compact, contains calcite.
136.	Indiana,	Decher's Point,	S. Palmer,	Freeport Lower limestone,	Bluish gray, brittle.
137.	Indiana,	Blairville,	P. Brown,	Freeport Lower limestone,	Bluish gray, brittle.
138.	Indiana,	Smithport,	A. Gorman,	Johnstown cement bed,	Upper part of deposit, hard.
139.	Indiana,	Smithport,	A. Gorman,	Johnstown cement bed,	Lower part of deposit, hard.
140.	Indiana,	Black Lick Station,	Tyhawk,	Johnstown cement bed,	Bluish gray, compact.
141.	Indiana,	Smith's Station, Blairsville,	.....	.....	.....
142.	Indiana,	Marion Center,	Robert Smith,	Sewickly limestone,	Compact, contains calcite.
143.	Indiana,	Marion Center,	J. H. Rochester,	.....	Compact gray, red tinge, coarse top seam.
144.	Indiana,	Marion Center,	J. H. Rochester,	.....	Red, middle seam.
145.	Indiana,	Home,	T. St. Clair Thompson,	.....	Red, bottom seam.
146.	Indiana,	Home,	T. St. Clair Thompson,	.....	Surface rock.
147.	Indiana,	Home,	T. St. Clair Thompson,	.....	.....

153.	Jefferson.	Junietta.	Mr. Rodgers.	Lower Barren Measures.	Bluish gray, brittle.
159.	Jefferson.	Big Run.	Jas. Smith.	Lower Barren Measures.	Pearl gray, hard and tough.
160.	Jefferson.	Big Run.	James Smith.	Freeport Upper limestone.	Bluish gray, brittle, calcite.
161.	Jefferson.	Brookwayville.	N. B. Lane.	Freeport Upper limestone.	Pearl gray, sandy.
162.	Jefferson.	Ferryville.	John Iler.	Freeport Upper limestone.	Bluish gray, brittle, calcite.
163.	Jefferson.	Ferryville.	John Iler.	Freeport Upper limestone.	Bluish gray, brittle, calcite.
164.	Jefferson.	Ferryville.	D. Hoffman.	Freeport Upper limestone.	Pearl gray, brittle, calcite.
165.	Jefferson.	Worthville.	N. B. Lane.	Freeport Lower limestone.	Brownish gray, brittle.
166.	Jefferson.	Brookwayville.	N. B. Lane.	Freeport Lower limestone.	Brownish gray, brittle.
167.	Jefferson.	Brookwayville.	John Iler.	Johnston's cement bed.	Dark gray, hard, tough.
168.	Jefferson.	Brookwayville.	C. Bovaard.	Feriferous limestone.	Dark gray, hard, tough.
169.	Jefferson.	Brookwayville.	W. Hanna.	Feriferous limestone.	Pearl gray, brittle.
170.	Jefferson.	Brookwayville.	A. Enty.	Feriferous limestone.	Bluish gray, hard, fossiliferous.
171.	Jefferson.	Brookwayville.	S. Shields.	Feriferous limestone.	Bluish gray, brittle, fossiliferous.
172.	Jefferson.	Brookwayville.	McHoan & Brother.	Feriferous limestone.	Pearl gray, calcite, fossiliferous.
173.	Jefferson.	Brookwayville.	Chestnut Hill Iron Ore Co.	Feriferous limestone.	Bluish gray, hard, tough, sandy.
174.	Jefferson.	Brookwayville.	Haldeman.	Feriferous limestone.	Quarry worked 50 yrs., 10,000 cu. yds. per year.
175.	Jefferson.	Brookwayville.	Haldeman.	Feriferous limestone.	For building and land.
176.	Jefferson.	Brookwayville.	Haldeman.	Feriferous limestone.	Light bluish gray, hard and brittle, South quarry.
177.	Jefferson.	Brookwayville.	Haldeman.	Feriferous limestone.	Light brownish gray, hard and brittle, North quarry.
178.	Jefferson.	Brookwayville.	Haldeman.	Feriferous limestone.	Dark bluish gray, hard and tough, North quarry.
179.	Jefferson.	Brookwayville.	Haldeman.	Feriferous limestone.	Brownish gray, crumbling, North quarry.
180.	Jefferson.	Brookwayville.	Haldeman.	Feriferous limestone.	Bluish gray, brittle, calcite.
181.	Jefferson.	Brookwayville.	Haldeman.	Feriferous limestone.	Pearl gray, brittle, calcite.
182.	Jefferson.	Brookwayville.	Haldeman.	Feriferous limestone.	Bluish gray, brittle, calcite.
183.	Jefferson.	Brookwayville.	Haldeman.	Feriferous limestone.	Bluish gray, brittle, calcite.
184.	Jefferson.	Brookwayville.	Haldeman.	Feriferous limestone.	Used for glass mfg.
185.	Jefferson.	Brookwayville.	Haldeman.	Feriferous limestone.	Brecciated limestone, blue and gray.
186.	Jefferson.	Brookwayville.	Haldeman.	Feriferous limestone.	Hard limestone, bluish gray, pyrites.
187.	Jefferson.	Brookwayville.	Haldeman.	Feriferous limestone.	Soft limestone, dark blue, laminated.
188.	Jefferson.	Brookwayville.	Haldeman.	Feriferous limestone.	Slatey, dark blue.
189.	Jefferson.	Brookwayville.	Haldeman.	Feriferous limestone.	Some quartz, bluish gray.
190.	Jefferson.	Brookwayville.	Haldeman.	Feriferous limestone.	
191.	Jefferson.	Brookwayville.	Haldeman.	Feriferous limestone.	
192.	Jefferson.	Brookwayville.	Haldeman.	Feriferous limestone.	
193.	Jefferson.	Brookwayville.	Haldeman.	Feriferous limestone.	
194.	Jefferson.	Brookwayville.	Haldeman.	Feriferous limestone.	

Compilation number.	County.	Town.	Owner.	Geological Formation.	Remarks.
196.	Lehigh.	Ironton.	Ironton R. R. Co.	Miluro Cambrian limestone Form. No. II.	Hard, compact, bluish gray.
196.	Lehigh.	Alburtia.	Thomas Iron Co.	.....	Bluish gray.
197.	Lehigh.	Alburtia.	Thomas Iron Co.	.....	Bluish gray, crystalline.
198.	Lehigh.	Troxilertown.	Mrs. Kuhn.	.....	Bluish gray, siliceous.
199.	Lehigh.	Troxilertown.	Frans.	.....	Dark blue, siliceous.
200.	Lehigh.	Alburtia.	.....	.....	Disintegrated.
201.	Lehigh.	Alburtia.	.....	.....	Fresh, 1 1/2 in. under No. 90.
202.	Lehigh.	Alburtia.	Ruths, Thos. Iron Co.	.....	.....
203.	Lycoming.	Jersey shore, Porter township.	Wilson.	Lewistown limestone No. VI.	Bluish gray, soft.
204.	Lycoming.	Jersey shore, Porter township.	Ferguson.	Lewistown limestone No. VI.	Bluish gray, hard, compact, calc.
205.	Lycoming.	Jersey shore, Porter township.	.....	.....	Bluish gray, hard.
206.	Mifflin.	Belleville.	Halley.	Lewistown limestone No. VI.	.....
206.	Mifflin.	Belleville.	D. Campbell.	Miluro Cambrian limestone Form. No. II.	Fossiliferous, contains oolite.
207.	Mifflin.	Belleville.	A. Campbell.	Miluro Cambrian limestone Form. No. II.	Probably top of Califerous, black and gray.
208.	Mifflin.	Belleville.	A. Campbell.	Miluro Cambrian limestone Form. No. II.	Bottom of Chazy, hard, light bluish gray.
209.	Mifflin.	Belleville.	Greenwood Ore Bank.	Miluro Cambrian limestone Form. No. II.	Magnesian limestone, contains calcite.
210.	Monroe.	Rosardville.	F. M. Miller.	Dolomite stratum.	For building and lime.
211.	Montgomery.	Port Kender.	Todd & Son.	.....	Carbonaceous matter 0.12.
212.	Montgomery.	Whitemarsh township.	G. W. H. Conson.	.....	Comminuted shells, siliceous matrix, reddish.
213.	Montgomery.	King of Prussia.	Schwayer & Liesa.	Chemung limestone.	.....
214.	Perry.	Newport.	.....	Chemung limestone.	Comminuted shells, siliceous matrix, reddish.
215.	Perry.	Newport.	.....	Chemung limestone.	.....
216.	Perry.	Newport.	.....	Chemung limestone.	.....

217.	Perry,	Mahoney Valley,	Still,	Lewistown limestone,	Dark blue, brittle, slaty.
218.	Perry,	Mahoney Valley,	Still,	Lewistown limestone,	Bluish gray, brittle, fossiliferous, calcite.
219.	Somerset,	Somerset,	Zimmerman,	Johnstown cement bed,	Bluish gray, compact, hard.
220.	Somerset,	Friedensburg,	Reitz,	Johnstown cement bed,	Bluish gray, compact, sandy.
221.	Somerset,	Stoytown,	Wilt,	Johnstown cement bed,	Bluish gray, compact.
222.	Somerset,	Spiesville,	J. J. Pile,	Johnstown cement bed,	Bluish gray, compact, brittle.
223.	Somerset,	Jenner Cross Roads,	J. W. Beam,	Johnstown cement bed,	Compact, upper bench of quarry.
224.	Somerset,	Jenner Cross Roads,	J. W. Beam,	Johnstown cement bed,	Compact, middle bench of quarry.
225.	Somerset,	Jenner Cross Roads,	J. W. Beam,	Johnstown cement bed,	Compact, lower bench of quarry.
226.	Somerset,	Shade township,	Lodgers,	Johnstown cement bed,	Bluish gray, hard, sandy.
227.	Somerset,	Davidville,	Revorrow,	Johnstown cement bed,	Bluish gray, brittle.
228.	Somerset,	Calp Level,	Weaver,	Johnstown cement bed,	Bluish gray, compact.
229.	Somerset,	Salisbury,	S. S. Flickenger,	Little Pittsburgh limestone,	Slaty, contains coal, much pyrite.
230.	Somerset,	Urdina,	Pittsburgh Coal, Coke & Iron Co.,	Elk Lick limestone,	Bluish gray, compact.
231.	Somerset,	Meyersdale,	Elias Yoder,	Elk Lick limestone,	Bluish gray, compact.
232.	Somerset,	Jenner Cross Roads,	Peter Berkey,	Elk Lick limestone,	Bluish gray, compact.
233.	Somerset,	Salisbury,	M. J. Beechy,	Redstone limestone,	Pearl gray, crystalline.
234.	Somerset,	Buckstown,	Burkitt, .....	.....	Concretionary nodules of greenish limestone.
235.	Somerset,	Forwardstown,	Harshberger, .....	.....	Bluish black, compact, contains pyrites.
236.	Somerset,	Meyersdale,	Keystone Coal and Mfg. Co.,	Great limestone,	Bluish gray, hard compact, Fe as carbonate.
237.	Somerset,	Meyersdale,	Saylor Hill,	Great limestone,	Bluish gray, brittle, compact, Fe as carbonate.
238.	Somerset,	Meyersdale,	Saylor Hill,	Sewickly limestone,	Yellowish gray, brittle, compact, Fe as carbonate.
239.	Somerset,	Salisbury,	J. M. Hayes,	Sewickly limestone,	Bluish gray, brittle, hard, Fe as carbonate.
240.	Sullivan,	Millview,	Lucke,	Chemung Formation limestone No. VIII,	Fossiliferous, contains calcite, rose tinted, upper bench.
241.	Sullivan,	Millview,	Lucke,	Chemung Formation limestone No. VIII,	Fossiliferous, contains calcite, rose tinted, lower bench.
242.	Tioga,	Mansfield,	G. R. Wilson,	Chemung Formation limestone No. VIII,	Contains comminuted sea shells and shale.
243.	Washington,	Canonsburg, .....	.....	Great lower limestone division,	Fe reckoned as carbonate.
244.	Washington,	Canonsburg, .....	.....	Great lower limestone division,	Fe reckoned as carbonate.
245.	Washington,	Canonsburg, .....	.....	Great lower limestone division,	Fe reckoned as carbonate.
246.	Washington,	Somerset, .....	.....	Great lower limestone division,	Fe reckoned as carbonate.
247.	Washington,	Washington, .....	.....	Upper Washington limestone,	Fe reckoned as carbonate.
248.	Wayne,	Cherry Ridge township, .....	.....	Catskill limestone,	Reddish gray, brecciated, contains malachite.
249.	Wayne,	Cherry Ridge township, .....	.....	Catskill limestone,	Greenish gray, siliceous.
250.	Wayne,	Oregon township, .....	.....	Catskill limestone,	Greenish gray, sandy.
251.	Wayne,	Oregon township,	Wining & Cuisan,	Catskill limestone,	Pearl gray, compact, brittle, calcite.
252.	Westmoreland,	Kelley's Station, .....	.....	Upper limestone,	Reddish gray, brittle.
253.	Westmoreland,	Salina,	Kier Bros.,	Upper limestone,	Reddish gray, brittle.

Compilation number.	County.	Town.	Owner.	Geological Formation.	Remarks.
254.	Westmoreland,	Mt. Pleasant,	Freeman, .....	.....	So-called "Black ore," sandy looking.
255.	York,	Wrightsville,	Kerr Bros., .....	.....	For lime and fluxes.
256.	York,	Dillsburg, .....	.....	.....	Greenish gray.
257.	York,	Xenia P. O., .....	.....	.....	Greenish gray, contains manganese.
258.	York, .....	.....	.....	.....	Conglomerate limestone.
259.	York,	Settland, .....	.....	.....	White crystalline limestone.
260.	York,	Wrightsville, .....	.....	.....	.....
261.	York,	Mengis Mill Station,	Sprenkel,	Shuro-Cambrian limestone Form. No. II,	Greenish gray, and pink, compact and laminated.
262.	York,	Mengis Mill Station,	Sprenkel,	Shuro-Cambrian limestone Form. No. II,	Blue gray, contains magnetic oxide of Fe.
263.	York,	Dillsburg,	Welty,	Mesozoic limestone,	Greenish gray, hard, tough, brecciated.
264.	York,	Dillsburg,	Welty,	Mesozoic limestone,	Greenish gray, hard, tough, brecciated.
265.	York,	Dillsburg,	Welty,	Mesozoic limestone,	Greenish gray, hard, tough, brecciated.
266.	York,	Dillsburg,	Welty,	Mesozoic limestone,	Greenish gray, hard, tough, brecciated.
267.	York,	Dillsburg,	Welty,	Mesozoic limestone,	Greenish gray, hard, tough, brecciated.
268.	York,	Harover,	Hittinger & Eberley,	Mesozoic limestone,	Greenish gray, hard, tough, brecciated.
269.	York,	Wrightsville,	C. Kerr, .....	.....	Greenish gray, hard, tough, brecciated.
270.	York,	Wrightsville,	C. Kerr, .....	.....	Greenish gray, hard, tough, brecciated.
271.	York,	Wrightsville,	C. Kerr, .....	.....	Greenish gray, hard, tough, brecciated.
272.	York,	Wrightsville,	C. Kerr, .....	.....	Greenish gray, hard, tough, brecciated.
273.	York,	Wrightsville,	C. Kerr, .....	.....	Greenish gray, hard, tough, brecciated.

Compilation number.	Analyst.	No. of analysis.	References.	Insoluble matter.	Oxid of iron and alumina, Fe ₂ O ₃ and Al ₂ O ₃ .	Carbonate of lime, CaCO ₃ .	Carbonate of magnesia, MgCO ₃ .	Sulfuric acid, SO ₃ .	Phosphoric acid, P ₂ O ₅ .	Other Constituents.	Undetermined.
1.		291	Page 83 M ₂ , 1879-1880, 2d Geol. Surv. Pa.,...	9.520	2.568	84.557	1.868	.....	0.065*	.....	1.138
2.		292	83 M ₂ , 1879-1880, 2d Geol. Surv. Pa.,...	0.880	0.964	96.453	1.445	.....	0.016*	.....	0.892
3.		293	83 M ₂ , 1879-1880, 2d Geol. Surv. Pa.,...	2.200	1.340	93.214	2.065	.....	0.009*	.....	1.172
4.		294	83 M ₂ , 1879-1880, 2d Geol. Surv. Pa.,...	3.170	1.207	98.571	1.824	.....	0.067*	.....	0.661
5.		295	84 M ₂ , 1879-1880, 2d Geol. Surv. Pa.,...	5.060	2.567	88.689	1.513	.....	0.048*	.....	2.013
6.		296	84 M ₂ , 1879-1880, 2d Geol. Surv. Pa.,...	1.820	1.246	94.928	1.210	.....	0.041*	.....	0.945
7.		297	84 M ₂ , 1879-1880, 2d Geol. Surv. Pa.,...	1.860	1.262	94.922	1.574	.....	0.028*	.....	0.774
8.		298	84 M ₂ , 1879-1880, 2d Geol. Surv. Pa.,...	1.860	1.262	94.922	1.574	.....	0.028*	.....	0.774
9.		299	84 M ₂ , 1879-1880, 2d Geol. Surv. Pa.,...	7.310	3.967	88.689	1.750	.....	0.148*	.....	1.172
10.		300	84 M ₂ , 1879-1880, 2d Geol. Surv. Pa.,...	4.520	2.567	88.689	2.592	.....	0.136*	.....	0.832
11.		301	85 M ₂ , 1879-1880, 2d Geol. Surv. Pa.,...	23.840	7.730	53.750	9.899	.....	0.306*	.....	0.832
12.		302	85 M ₂ , 1879-1880, 2d Geol. Surv. Pa.,...	22.260	7.450	64.160	1.538	.....	0.698*	.....	2.574
13.		303	85 M ₂ , 1879-1880, 2d Geol. Surv. Pa.,...	2.030	1.288	95.535	0.967	0.064	0.082	Mn ₂ O ₃ , 206. H ₂ O, 150	0.165
14.		304	85 M ₂ , 1879-1880, 2d Geol. Surv. Pa.,...	0.790	1.462	96.007	1.498	.....	0.078*	.....	0.444
15.		305	86 M ₂ , 1879-1880, 2d Geol. Surv. Pa.,...	2.300	1.333	94.721	1.044	.....	0.108*	.....	0.444
16.		306	86 M ₂ , 1879-1880, 2d Geol. Surv. Pa.,...	2.110	0.930	95.567	1.422	.....	0.090*	.....	0.072
17.		307	86 M ₂ , 1879-1880, 2d Geol. Surv. Pa.,...	2.100	2.089	94.185	1.483	.....	0.071*	.....	0.072
18.		308	86 M ₂ , 1879-1880, 2d Geol. Surv. Pa.,...	3.420	1.667	93.246	1.740	.....	0.074*	.....	0.099
19.		309	86 M ₂ , 1879-1880, 2d Geol. Surv. Pa.,...	3.220	1.713	93.232	0.968	.....	0.103*	.....	0.351
20.		310	298 M ₂ , 1876-8, 2d Geol. Surv. Pa.,...	0.370	1.000	96.785	1.278	0.150*	0.066*	.....	0.099
21.		311	301 M ₂ , 1876-8, 2d Geol. Surv. Pa.,...	2.500	0.842	96.684	1.647	0.258*	0.034*	.....	0.351
22.		312	302 M ₂ , 1876-8, 2d Geol. Surv. Pa.,...	3.000	0.644	95.089	1.581	0.078*	0.046*	.....	0.351
23.		313	303 M ₂ , 1876-8, 2d Geol. Surv. Pa.,...	3.020	0.570	95.571	1.521	0.068*	0.021*	.....	0.351
24.		314	304 M ₂ , 1876-8, 2d Geol. Surv. Pa.,...	1.000	10.004	95.231	1.283	0.138*	0.007*	FeCO ₃ , 0.745	0.351
25.		315	305 M ₂ , 1876-8, 2d Geol. Surv. Pa.,...	1.810	1.810	95.231	1.283	0.138*	0.007*	FeCO ₃ , 0.745	0.351
26.		316	306 M ₂ , 1876-8, 2d Geol. Surv. Pa.,...	10.810	10.048	95.231	1.283	0.138*	0.007*	FeCO ₃ , 0.745	0.351
27.		317	307 M ₂ , 1876-8, 2d Geol. Surv. Pa.,...	2.000	.....	95.231	1.283	0.138*	0.007*	FeCO ₃ , 0.745	0.351
28.		318	308 M ₂ , 1876-8, 2d Geol. Surv. Pa.,...	.....	.....	95.231	1.283	0.138*	0.007*	FeCO ₃ , 0.745	0.351
29.		319	309 M ₂ , 1876-8, 2d Geol. Surv. Pa.,...	1.400	1.600	94.480	2.570	.....	trace	.....	2.00
30.		320	310 M ₂ , 1876-8, 2d Geol. Surv. Pa.,...	1.600	2.600	92.900	2.880	.....	trace	.....	2.00
31.	S. S. Hartnaff.	786	306 M ₂ , 1876-8, 2d Geol. Surv. Pa.,...	0.910	0.264	94.990	3.866	0.138*	0.028*	.....	0.219
32.		807	306 M ₂ , 1876-8, 2d Geol. Surv. Pa.,...	3.210	1.126	78.196	17.510	0.273*	0.044*	.....	0.219
33.		961a	306 M ₂ , 1876-8, 2d Geol. Surv. Pa.,...	8.570	1.850	78.176	10.746	0.873*	0.066*	.....	0.219

*Recalculated. †Al₂O₃ only.

Compilation number.	Analyst.	No. of analysis.	References.	Insoluble matter.	Oxid of iron and alumina, Fe_2O_3 and Al_2O_3 .	Carbonate of lime, CaCO_3 .	Carbonate of magnes- ia, MgCO_3 .	Sulfuric acid, SO_3 .	Phosphoric acid, P_2O_5 .	Other Constituents.	Undetermined.
34.			Pase.								
35.		964b	306 M, 1876-8, 2d Geol. Surv. Pa.	4.330	0.640	91.892	2.875	0.243°	0.060°		
36.		964c	306 M, 1876-8, 2d Geol. Surv. Pa.	1.330	0.234	64.571	44.180	0.005°	0.007°		
37.		1,011a	306 M, 1876-8, 2d Geol. Surv. Pa.	5.880	1.932	90.389	2.245			Fe as carbonate.	
38.		1,011b	306 M, 1876-8, 2d Geol. Surv. Pa.	3.620	0.189	92.115	4.234			Fe as carbonate.	
39.		85	307 M, 1876-8, 2d Geol. Surv. Pa.	10.380	2.950	48.080	37.870	1.153°	0.098°		
40.		86	307 M, 1876-8, 2d Geol. Surv. Pa.	29.100	1.190	53.870	41.320	0.113°	0.030°		
41.		259	307 M, 1876-8, 2d Geol. Surv. Pa.	18.010	7.941	73.250°	2.325°	0.167	0.279		0.567
42.	Brook Iron Co.,										
43.	W. C. Henderson,		80 Catalogue of Exhibits.	0.350	0.400	54.340	43.980				0.300
44.				2.10	1.400	54.440				SiO_2 , 1.67	1.890
45.	Clement G. Smith,			2.770	11.510	73.730	30.100°			SiO_2 , 2.34	
46.				trace	trace	63.530	30.260°			SiO_2 , trace.	6.500
47.				3.900	0.900	75.500	19.500		trace		2.780
48.		596	297 MM 1876-8, 2d Geol. Surv. Pa.	2.770	1.823	92.453	1.544	0.075°	0.108°		0.186
49.		599	297 MM 1876-8, 2d Geol. Surv. Pa.	7.060	2.324	88.464	1.445	0.243°	0.065°		0.423
50.		600	297 MM 1876-8, 2d Geol. Surv. Pa.	4.780	1.291	91.607	1.556	0.725°	0.069°		
51.		555	297 MM 1876-8, 2d Geol. Surv. Pa.	4.800	1.589	91.069	1.587	0.118°	0.062°		0.525
52.		273	80 M, 1878-80, 2d Geol. Surv. Pa.	2.310	4.503	72.371	20.581	0.023°	0.108°	Mn_2O_3 , 4.81	
53.		279	80 M, 1878-80, 2d Geol. Surv. Pa.	8.410	4.503	72.371	20.581	0.023°	0.108°		
54.	Walton Quarries,		340 MM 1876-8, 2d Geol. Surv. Pa.	1.270	0.371	86.357	5.236	0.065°	0.080°		
55.	Walton Quarries,		341 MM 1876-8, 2d Geol. Surv. Pa.	0.670	0.900	97.723	0.903				0.387
56.	Walton Quarries,		342 MM 1876-8, 2d Geol. Surv. Pa.	0.620	0.340	95.121	1.952				
57.	Walton Quarries,		343 MM 1876-8, 2d Geol. Surv. Pa.	1.230	0.340	95.121	1.134				
58.	Walton Quarries,		344 MM 1876-8, 2d Geol. Surv. Pa.	15.250	9.350	85.372	1.349				
59.	Walton Quarries,		345 MM 1876-8, 2d Geol. Surv. Pa.	13.500	2.630	83.084	33.457				
60.	Walton Quarries,		346 MM 1876-8, 2d Geol. Surv. Pa.	6.660	0.900	90.013	32.828				
61.	Walton Quarries,		347 MM 1876-8, 2d Geol. Surv. Pa.	7.730	1.090	87.036	29.423				
62.	J. A. Fries,	10,640	Pa. Expt. Station records,	6.510		63.690	2.530				8.710
63.	J. A. Fries,	10,641	Pa. Expt. Station records,	5.960		91.210	2.210				4.360
64.	J. A. Fries,	10,642	Pa. Expt. Station records,	16.070		66.940	2.230				14.740
65.	J. A. Fries,	10,643	Pa. Expt. Station records,	5.890		87.730	1.620				0.630
66.	W. S. Sweetser,	26,169	Pa. Expt. Station records,	8.540		84.530					3.380

* Al_2O_3 only.

Compilation number.	Analyst.	No. of analysis.	References.	Insoluble matter.	Oxide of iron and aluminum, Fe_2O_3 and Al_2O_3 .	Carbonate of lime, CaCO_3 .	Carbonate of magnesia, MgCO_3 .	Sulfuric acid, H_2SO_4 .	Phosphoric acid, P_2O_5 .	Other Constituents.	Undetermined.
115.		41	237 MM 2d G. S., 1876-8.	10.770	2.200	80.647	2.217	0.003	0.006	$\text{FeS}, 1.126 \text{ H}_2\text{O}, 1.010$ Carbon. matter.	1.250
116.		594	239 MM 2d G. S., 1876-8.	9.460	5.990	86.471	17.711	0.200*	0.110*	.....	0.063
117.		595	240 MM 2d G. S., 1876-8.	7.360	8.120	87.868	1.723	0.265*	0.115*	.....	0.510
118.		596	30 M, 2d G. S., 1876-8.	56.160	2.120	40.642	1.421	.....	0.041*	$\text{FeCO}_3, 1.914$.	0.463
119.		597	30 M, 2d G. S., 1876-8.	8.160	2.160	85.418	4.691	.....	0.030*	.....	0.100
120.		598	30 M, 2d G. S., 1876-8.	2.160	0.941	85.393	42.698	.....	0.030*	.....	.....
121.		599	31 M, 2d G. S., 1876-8.	4.090	0.543	51.743	43.436	.....	0.035*	.....	.....
122.		600	31 M, 2d G. S., 1876-8.	0.860	0.260	97.321	1.266	.....	0.031*	.....	0.130
123.		601	31 M, 2d G. S., 1876-8.	1.760	0.700	67.375	30.702	.....	0.018*	.....	0.142
124.		602	32 M, 2d G. S., 1876-8.	29.640	6.760	47.375	15.581	.....	0.018*	.....	0.644
125.		603	80 Catalogue of Exhibits.	.....	0.800	92.950*	2.070*	.....	0.020*	.....	2.910
126.		560	302 MM 2d G. S., 1876-8.	5.700	0.123†	90.904	2.162	0.203*	0.023*	$\text{FeCO}_3, 1.642$.	.....
127.	D. McCreath.	527	302 MM 2d G. S., 1876-8.	2.330	0.697	94.035	1.965	0.140*	0.077*	Fe as carbonate.	0.806
128.	D. McCreath.	528	302 MM 2d G. S., 1876-8.	5.040	1.139	91.125	1.573	0.075*	0.032*	Fe as carbonate.	1.017
129.	D. McCreath.	532	303 MM 2d G. S., 1876-8.	5.300	1.783	89.232	2.557	0.148*	0.062*	Fe as carbonate.	0.853
130.	D. McCreath.	534	303 MM 2d G. S., 1876-8.	49.030	1.667	47.300	2.011	0.345*	0.063*	.....	.....
131.		536	303 MM 2d G. S., 1876-8.	8.150†	1.260†	70.557*	18.099*	.....	.....	$\text{FeCO}_3, 1.067$.	0.907
132.		561	303 MM 2d G. S., 1876-8.	6.320	0.550	84.018*	9.424*	.....	.....	$\text{FeCO}_3, 0.927 \text{ H}_2\text{O}$.	.....
133.		535	303 MM 2d G. S., 1876-8.	33.220	14.066	25.198*	19.638*	.....	.....	1.062.	1.492
134.	S. S. Hartnutt.	735	305 MM 2d G. S., 1876-8.	8.220	1.439	88.687	1.850	0.410*	0.009*	.....	.....
135.	S. S. Hartnutt.	680	305 MM 2d G. S., 1876-8.	42.400	16.739	82.522	2.561	0.140*	0.070*	.....	0.971
136.	S. S. Hartnutt.	681	305 MM 2d G. S., 1876-8.	34.640	0.180†	92.323	2.089	0.063*	0.037*	$\text{FeCO}_3, 0.683$.	10.962
137.		552	298 MM 2d G. S., 1876-8.	4.640	0.180†	92.323	1.089	0.063*	0.037*	.....	0.943
138.		764	293 MM 2d G. S., 1876-8.	10.327	2.530	82.768	2.875	0.390*	0.035*	.....	0.785
139.		765	293 MM 2d G. S., 1876-8.	9.021	3.220	84.135	5.196	0.183*	0.035*	.....	1.221
140.		773	293 MM 2d G. S., 1876-8.	9.150	2.130	84.407	2.800	0.470*	0.041*	.....	1.013
141.		771	293 MM 2d G. S., 1876-8.	5.430	1.710	89.321	1.801	0.333*	0.063*	.....	0.833
142.		714	293 MM 2d G. S., 1876-8.	14.960	4.190	72.284	6.469	0.170*	0.069*	.....	1.637
143.		769	293 MM 2d G. S., 1876-8.	27.200	6.970	54.768	8.437	0.230*	0.039*	.....	2.133
144.		765	293 MM 2d G. S., 1876-8.	2.090	2.030	92.557	1.839	0.468*	0.060*	.....	1.068
145.		770	366 MM 2d G. S., 1876-8.	16.540	5.710	85.892	9.686	0.730*	0.077*	.....	1.408
146.		766	293 MM 2d G. S., 1876-8.	8.210	1.960	88.232	1.371	0.130*	0.039*	.....	0.967
147.		762	293 MM 2d G. S., 1876-8.	5.602	2.680	82.321	8.071	0.265*	0.039*	.....	1.223
148.		768	294 MM 2d G. S., 1876-8.	32.790	4.360†	86.214	16.883	0.140*	0.135*	$\text{FeCO}_3, 8.078$.	1.407

|| Fe_2O_3 only.† Al_2O_3 only. ‡ SiO_2 only.

149.	294	MM 2d G. S., 1876-8.	15,000	7,380	58,750	18,005	0.108*	0.185*	.....	.....	2,507
150.	767	309	MM 2d G. S., 1876-8.	13,780	75,780	43,602	0.063*	0.087*	.....	.....	1,197
151.	767	309	MM 2d G. S., 1876-8.	12,180	5,540	43,602	0.063*	0.087*	.....	.....	1,084
152.	767	309	MM 2d G. S., 1876-8.	12,180	5,540	43,602	0.063*	0.087*	.....	.....	1,084
153.	20,910	Pa. Expt. Station Records.	36,060	.....	59,821	1,220	0.238*	.....	.....	.....	2,700
154.	20,910	Pa. Expt. Station Records.	20,910	.....	59,821	1,220	.....	.....	.....	.....	2,700
155.	20,910	Pa. Expt. Station Records.	20,910	.....	59,821	1,220	.....	.....	.....	.....	2,700
156.	22,464	A. N. Diehl.	11,450	3,100	83,880	8,190	.....	.....	.....	.....	54,580
157.	22,464	A. N. Diehl.	11,450	3,100	83,880	8,190	.....	.....	.....	.....	54,580
158.	22,464	A. N. Diehl.	11,450	3,100	83,880	8,190	.....	.....	.....	.....	54,580
159.	22,413	C. P. Belisle.	13,910	2,650	95,030	6,300	.....	.....	.....	.....	0,500
160.	217	87 M, 2d G. S., 1879-80.	2,880	1,580	94,500	2,497	.....	0.063*	.....	.....	0,500
161.	218	87 M, 2d G. S., 1879-80.	2,880	1,580	94,500	2,497	.....	0.063*	.....	.....	0,500
162.	219	87 M, 2d G. S., 1879-80.	11,780	3,790	77,143	4,091	.....	0.039*	.....	.....	1,080
163.	320	88 M, 2d G. S., 1879-80.	6,170	2,140	89,107	1,611	.....	0.167*	.....	.....	1,284
164.	321	88 M, 2d G. S., 1879-80.	16,060	7,250	94,871	2,762	.....	0.065*	.....	.....	2,429
165.	322	88 M, 2d G. S., 1879-80.	2,480	1,250	90,000	2,840	.....	0.074*	.....	.....	2,853
166.	323	88 M, 2d G. S., 1879-80.	2,130	1,212	88,878	2,521	.....	0.062*	.....	.....	2,853
167.	324	88 M, 2d G. S., 1879-80.	2,480	1,250	90,000	2,840	.....	0.062*	.....	.....	2,853
168.	325	88 M, 2d G. S., 1879-80.	2,070	1,170	87,038	1,558	.....	0.141*	.....	.....	0,708
169.	326	88 M, 2d G. S., 1879-80.	2,070	1,170	87,038	1,558	.....	0.141*	.....	.....	0,708
170.	327	89 M, 2d G. S., 1879-80.	23,500	7,790	51,410	3,982	.....	0.044*	.....	.....	1,023
171.	328	89 M, 2d G. S., 1879-80.	8,020	4,633	82,338	1,931	.....	0.076*	.....	.....	2,883
172.	329	89 M, 2d G. S., 1879-80.	1,910	1,815	94,392	1,702	.....	0.087*	.....	.....	2,854
173.	330	89 M, 2d G. S., 1879-80.	2,040	1,810	95,843	1,816	.....	0.071*	.....	.....	0,610
174.	331	89 M, 2d G. S., 1879-80.	1,300	0,990	96,428	0,908	.....	0.069*	.....	.....	1,123
175.	332	90 M, 2d G. S., 1879-80.	1,250	0,780	96,578	0,832	.....	0.078*	.....	.....	0,296
176.	333	90 M, 2d G. S., 1879-80.	51,450	4,760	89,428	1,816	.....	0.085*	.....	.....	0,445
177.	78	Catalogue of Exhibits.	3,200	59,520*	86,920*	7,000	.....	0.094*	.....	.....	2,452
178.	79	Catalogue of Exhibits.	7,000	86,000	7,000	.....	.....	.....	.....	.....	3,600
179.	779	309	MM 2d G. S., 1876-8.	0,438	0,517	54,760	.....	0.028*	.....	.....	0,960
180.	778	309	MM 2d G. S., 1876-8.	0,847	0,804	55,104	.....	0.063*	.....	.....	0,042
181.	780	309	MM 2d G. S., 1876-8.	1,923	0,869	55,517	.....	0.063*	.....	.....	0,045
182.	780	309	MM 2d G. S., 1876-8.	1,923	0,869	55,517	.....	0.063*	.....	.....	0,045
183.	746	297	MM 2d G. S., 1876-8.	1,970	0,731	50,339	.....	0.078*	.....	.....	0,274
184.	746	297	MM 2d G. S., 1876-8.	1,970	0,731	50,339	.....	0.078*	.....	.....	0,274
185.	746	297	MM 2d G. S., 1876-8.	3,070	1,583	93,840	.....	0.069*	.....	.....	0,274
186.	746	297	MM 2d G. S., 1876-8.	3,070	1,583	93,840	.....	0.069*	.....	.....	0,274
187.	26,759	M. E. McDonnell.	2,080	1,187	94,785	1,460	.....	0.308*	.....	.....	0,158
188.	20,759	Atlas Hercules and Cement Co.,	20,120	1,000*	85,000*	7,000*	.....	0.308*	.....	.....	0,158
189.	65	309	MM 2d G. S., 1876-8.	6,000†	.....	92,000	.....	.....	K ₂ O 1.00.	.....	0,330
190.	65	309	MM 2d G. S., 1876-8.	8,980	0,070†	49,318	.....	0.014*	FeCO ₃ , 1.035, FeS ₂ , 0.080, Carb. matter 0.250.	.....	.....
191.	66	209	MM 2d G. S., 1876-8.	10,750	0,140†	51,558	.....	0.041*	FeCO ₃ , 1.450, FeS ₂ , 0.611, Carbon mat-ter 0.210.	.....	0,024
192.	67	309	MM 2d G. S., 1876-8.	8,400	0,066†	86,696	.....	0.067*	FeCO ₃ , 0.538, FeS ₂ , 0.288, Carbon mat-ter 0.390.	.....	.....

*Recalculated. †Al₂O₃ only. Includes insoluble, ferric oxide and alumina.

Compilation number.	Analyst.	No. of analysis.	References.	Insoluble matter.	Oxide of iron and alumina, Fe_2O_3 and Al_2O_3 .	Carbonate of lime, CaCO_3 .	Carbonate of magnesia, MgCO_3 .	Sulfuric acid, SO_3 .	Phosphoric acid, P_2O_5 .	Other constituents.	Undetermined.
193.		63	310 MM 2d G. S., 1876-8.	11.070	0.960†	70.760	15.256		0.044*	FeCO_3 , 1.398, FeS_2 , 105, Carbon matter, 0.120.	
194.		69	310 MM 2d G. S., 1876-8.	10.930	0.300†	56.220	31.201		0.011*	FeCO_3 , 1.395, FeS_2 , 320, Carbon matter, 0.120.	0.467
195.	D. McCreath.	332	76 M 2d G. S., 1874-5.	7.860		53.632	5.432		0.060*	FeCO_3 , 1.158, FeS_2 , 123, Carbon matter, 0.586.	
196.	A. S. McCreath.		76 M 2d G. S., 1874-5.	5.650		51.920	41.071		0.023*		0.725
197.	A. S. McCreath.		76 M 2d G. S., 1874-5.	11.290		47.890	33.535	traces	0.045*		1.327
198.	A. S. McCreath.		76 M 2d G. S., 1874-5.	13.480		51.603	22.917	traces	0.037*		1.595
199.	A. S. McCreath.		76 M 2d G. S., 1874-5.	9.240		48.530	40.410	0.013*	0.027*		1.680
200.	Dr. Genth.		105 2d G. S., 1874-5.		2.360*	50.076*	43.150			SO_3 , 2.08, Fe_2O_3 , 0.57, MnO 0.35.	0.314
201.	Dr. Genth.		105 2d G. S., 1874-5.		0.700*	53.470*	42.800			SO_3 , 1.12, Fe_2O_3 , 1.21, MnO 0.44.	1.290
202.	H. Pemberton, Jr.		110 2d G. S., 1874-5.		1.130†	48.250*	36.370		traces	SO_3 , 12.13, Fe_2O_3 , 0.33.	1.293
203.		323	94 M, 2d G. S., 1879-80.	4.680		48.250*	1.740	0.093*			
204.		324	94 M, 2d G. S., 1879-80.	6.960		60.964	20.691	0.250*			
205.		325	94 M, 2d G. S., 1879-80.	5.570		72.156	20.304	0.419*	0.011*		
206.	S. S. Harranft.	764	308 MM 2d G. S., 1876-8.	4.426		27.951	1.131	0.093*	0.089*		
207.	S. S. Harranft.	765	308 MM 2d G. S., 1876-8.	4.260		27.173	2.315	0.089*	0.089*		
208.		761	308 MM 2d G. S., 1876-8.	8.010		54.235	36.109	0.373*	0.033*		
209.		763	308 MM 2d G. S., 1876-8.	2.850		54.235	1.530	0.110	0.030*		0.460
210.	McCreath.			0.250	0.900	53.190	45.450		0.020		0.190
211.			79 Catalogue of Exhibits.			53.000	46.000			SO_3 , 1.000, FeO 0.64.	2.000
212.	G. G. Pond.		81 Catalogue of Exhibits.		0.170†	36.180	1.680*		0.050*		1.063
213.		266	82 M, 2d G. S., 1879-80.	31.570		60.214	1.664		0.153*		1.185
214.		267	82 M, 2d G. S., 1879-80.	41.940		49.178	1.816		0.190*		2.351
215.		268	82 M, 2d G. S., 1879-80.	53.810		43.433	1.967		0.195*		2.347
216.		269	82 M, 2d G. S., 1879-80.	15.720		71.732	7.621		0.030*		0.791
217.		270	82 M, 2d G. S., 1879-80.	6.530		83.642	1.816		0.025*	Fe as carbonate.	1.326
218.		271	82 M, 2d G. S., 1879-80.	24.780		83.969	4.244	0.943*	0.325*		
219.		293	295 MM 2d G. S., 1876-8.		4.393						

† Al_2O_3 only.

220.	295 MM 2d G. S., 1876-8.	6.040	3.972	55.773	2.908	0.415*	0.204*	Fe as carbonate, FeCO ₃ , 1.786.	0.533
221.	295 MM 2d G. S., 1876-8.	5.640	3.247	83.139	1.854	0.383*	0.053*	Fe as carbonate, FeCO ₃ , 1.786.	1.233
222.	295 MM 2d G. S., 1876-8.	4.970	3.633	79.473	10.223	0.420*	0.078*	Fe as carbonate, FeCO ₃ , 1.167, Carb. matter .550.	1.139
223.	295 MM 2d G. S., 1876-8.	3.960	.369†	92.296	1.433	0.243*	0.041*	Fe as carbonate, FeCO ₃ , 1.167, Carb. matter .550.	0.041*
224.	295 MM 2d G. S., 1876-8.	12.020	1.629†	54.321	23.088	0.313*	0.117*	FeCO ₃ , 8.492, Carb. matter .380.	0.117*
225.	295 MM 2d G. S., 1876-8.	10.760	.403†	69.264	13.773	0.295*	0.108*	FeCO ₃ , 4.739, Carb. matter .560.	0.108*
226.	295 MM 2d G. S., 1876-8.	17.770	4.440†	33.940	16.060	0.220*	0.123*	FeCO ₃ , 6.900.	0.088
227.	295 MM 2d G. S., 1876-8.	3.930	0.231†	2.134	2.134	1.160*	0.060*	FeCO ₃ , 1.506.	2.357
228.	295 MM 2d G. S., 1876-8.	13.360	11.900	50.160	13.494	0.833*	0.270*	Fe as carbonate, FeCO ₃ , 1.506.	0.513
229.	295 MM 2d G. S., 1876-8.	20.660	1.100†	64.706	2.156	6.073*	1.820*	Fe as carbonate, FeCO ₃ , 1.506.	6.723
230.	295 MM 2d G. S., 1876-8.	3.740	1.995	90.803	2.738	0.210*	0.110*	Fe as carbonate, FeCO ₃ , 1.506.	0.413
231.	295 MM 2d G. S., 1876-8.	19.800	2.898†	55.589	14.324	0.463*	0.073*	FeCO ₃ , 1.813.	0.130
232.	295 MM 2d G. S., 1876-8.	2.600	0.294†	89.532	3.327	0.613*	0.037*	Fe as carbonate, FeCO ₃ , 1.813.	0.037*
233.	295 MM 2d G. S., 1876-8.	4.040	1.925	69.626	6.153	0.233*	0.053*	Fe as carbonate, FeCO ₃ , 1.813.	1.073
234.	295 MM 2d G. S., 1876-8.	37.940	3.317	51.921	3.630	0.203*	0.234*	MnCO ₃ , 0.585, FeCO ₃ , 3.069.	0.234*
235.	295 MM 2d G. S., 1876-8.	4.903	0.455	90.538	8.445	0.060*	0.060*	MnCO ₃ , 1.400, FeCO ₃ , 3.314, FeS, 3.371.	0.564
236.	D. McCreatch.	9.180	3.211	72.623	12.614	0.398*	0.011*	FeCO ₃ , 1.400, FeCO ₃ , 3.314, FeS, 3.371.	1.943
237.	D. McCreatch.	6.220	2.871	85.732	5.098	0.260*	0.085*	FeCO ₃ , 1.400, FeCO ₃ , 3.314, FeS, 3.371.	0.13
238.	D. McCreatch.	9.790	5.301	69.160	15.535	0.115*	0.089*	FeCO ₃ , 1.400, FeCO ₃ , 3.314, FeS, 3.371.	0.13
239.	D. McCreatch.	11.510	6.830	74.803	6.724	0.130*	0.160*	FeCO ₃ , 1.400, FeCO ₃ , 3.314, FeS, 3.371.	0.160*
240.	D. McCreatch.	5.240	5.196	80.398	5.653	0.600*	0.205*	FeCO ₃ , 1.400, FeCO ₃ , 3.314, FeS, 3.371.	0.205*
241.	D. McCreatch.	17.860	5.570	69.000	5.357	0.230*	0.230*	FeCO ₃ , 1.400, FeCO ₃ , 3.314, FeS, 3.371.	0.230*
242.	D. McCreatch.	41.700	4.411	51.539*	2.291*	0.067*	0.067*	FeCO ₃ , 1.400, FeCO ₃ , 3.314, FeS, 3.371.	0.067*
243.	D. McCreatch.	22.620	7.146	48.823	20.621	0.197*	0.197*	FeCO ₃ , 1.400, FeCO ₃ , 3.314, FeS, 3.371.	0.197*
244.	D. McCreatch.	15.750	7.511	41.590	24.423	0.217*	0.217*	FeCO ₃ , 1.400, FeCO ₃ , 3.314, FeS, 3.371.	0.217*
245.	D. McCreatch.	12.780	8.613	41.623	24.423	0.215*	0.215*	FeCO ₃ , 1.400, FeCO ₃ , 3.314, FeS, 3.371.	0.215*
246.	D. McCreatch.	17.800	8.613	72.750	20.943	0.315*	0.315*	FeCO ₃ , 1.400, FeCO ₃ , 3.314, FeS, 3.371.	0.315*
247.	D. McCreatch.	17.330	2.923	72.866	8.813	0.338*	0.141*	FeCO ₃ , 1.400, FeCO ₃ , 3.314, FeS, 3.371.	0.141*
248.	D. McCreatch.	23.800	4.126	64.332	1.816	0.116*	0.116*	FeCO ₃ , 1.400, FeCO ₃ , 3.314, FeS, 3.371.	0.116*
249.	D. McCreatch.	65.470	8.908	19.755	3.513	0.217*	0.217*	FeCO ₃ , 1.400, FeCO ₃ , 3.314, FeS, 3.371.	0.217*
250.	D. McCreatch.	75.230	17.694	1.589	1.589	0.078*	0.078*	FeCO ₃ , 1.400, FeCO ₃ , 3.314, FeS, 3.371.	0.078*
251.	D. McCreatch.	80.950	11.196	1.664	1.664	0.063*	0.063*	FeCO ₃ , 1.400, FeCO ₃ , 3.314, FeS, 3.371.	0.063*
252.	D. McCreatch.	4.015	1.520	91.962	1.664	0.223*	0.023*	FeCO ₃ , 1.400, FeCO ₃ , 3.314, FeS, 3.371.	0.023*
253.	D. McCreatch.	0.990	2.720	94.643	1.144	0.070*	0.070*	FeCO ₃ , 1.400, FeCO ₃ , 3.314, FeS, 3.371.	0.070*
254.	D. McCreatch.	38.240	6.002†	12.357	4.037	1.265*	1.265*	FeCO ₃ , 1.400, FeCO ₃ , 3.314, FeS, 3.371.	1.265*
255.	D. McCreatch.	3.000	97.100	2.600	2.600	0.200*	0.200*	FeCO ₃ , 1.400, FeCO ₃ , 3.314, FeS, 3.371.	0.200*
256.	D. McCreatch.	21.600	30.743*	73.190	4.870	0.200*	0.200*	FeCO ₃ , 1.400, FeCO ₃ , 3.314, FeS, 3.371.	0.200*
257.	D. McCreatch.	20.060	37.536*	62.350	6.330	0.200*	0.200*	FeCO ₃ , 1.400, FeCO ₃ , 3.314, FeS, 3.371.	0.200*
258.	D. McCreatch.	15.390	31.939*	77.880	2.830	0.200*	0.200*	FeCO ₃ , 1.400, FeCO ₃ , 3.314, FeS, 3.371.	0.200*
259.	D. McCreatch.	4.300	40.423*	93.570	0.960	0.200*	0.200*	FeCO ₃ , 1.400, FeCO ₃ , 3.314, FeS, 3.371.	0.200*
260.	D. McCreatch.	5.650	12.070	84.791	31.460	0.200*	0.200*	FeCO ₃ , 1.400, FeCO ₃ , 3.314, FeS, 3.371.	0.200*
261.	D. McCreatch.	18.650	2.034	66.702*	10.286*	0.182	0.182	FeCO ₃ , 1.400, FeCO ₃ , 3.314, FeS, 3.371.	0.182

*Recalculated. †Al₂O₃ only. ‡Fe₂O₃ only.

Compilation number.	Analyst.	No. of analyses.	References.	Insoluble matter.	Oxid of iron and alumina, Fe ₂ O ₃ .	Carbonate of lime, CaCO ₃ .	Carbonate of magnesia, MgCO ₃ .	Sulphuric acid, SO ₃ .	Phosphoric acid, P ₂ O ₅ .	Other constituents.	Undetermined.
262.	431	303 MM 2d G. S., 1876-8.	13.310	7.454	68.707*	1.670*	trace	0.060	FeCO ₃ 2.587*, FeS ₂ 0.41, H ₂ O 1.055, .....	.....
263.	273	79 M ₂ 2d G. S., 1879-80.	14.010	2.400†	80.217*	10.823*	0.010*	0.025*	FeO 1.174, .....	.....
264.	274	79 M ₂ 2d G. S., 1879-80.	10.890	2.320†	78.915*	13.138*	0.008*	0.023*	FeO 0.084, .....	.....
265.	275	79 M ₂ 2d G. S., 1879-80.	10.460	1.690†	83.875*	7.899*	0.010*	0.007*	FeO 0.585, .....	.....
266.	276	79 M ₂ 2d G. S., 1879-80.	18.580	2.680†	76.630*	6.247*	0.008*	0.030*	FeO 1.093, .....	.....
267.	277	79 M ₂ 2d G. S., 1879-80.	27.010	5.060†	73.379*	6.010*	0.013*	0.077*	FeO 2.304, .....	.....
268.	Franklin Menges,	.....	.....	0.530	0.030	83.120	8.230	.....	0.100	K ₂ CO ₃ 4.23,	0.560
269.	24, 616	Pa. Expt. Station Records,	0.940	2.440	83.850	0.160	.....	.....	.....	.....
270.	25, 617	Pa. Expt. Station Records,	0.490	2.400	84.120	1.560	.....	.....	.....	1.210
271.	25, 618	Pa. Expt. Station Records,	0.490	0.400	84.120	1.560	.....	.....	.....	0.900
272.	25, 619	Pa. Expt. Station Records,	19.350	1.460	73.570	1.040	.....	.....	.....	.....
273.	25, 626	Pa. Expt. Station Records,	4.910	3.490	80.960	9.620	.....	.....	.....	.....

*Recalculated.

†Al₂O₃ only.

METHODS OF STEER-FEEDING.

A Co-operative Experiment by the Pennsylvania State Department of Agriculture and The Pennsylvania State College Agricultural Experiment Station.

BY G. C. WATSON AND M. S. McDOWELL, *State College, Pa.*

At the suggestion of the Secretary of Agriculture, the following experiment upon methods of handling fattening steers has been carried out by the Department of Agriculture and the Experiment Station in co-operation. It is recognized that one season's experiment with fifteen animals is far from sufficient to settle the questions involved, and this investigation is to be regarded as a preliminary report only. It is hoped to continue the trials through succeeding years.

The close margin on which fattening steers are being fed by the farmers of Pennsylvania, compels them to look carefully for little wastes that heretofore have gone unchecked, and to secure the most efficient means of caring for their fattening animals at the least possible expense. On account of this close competition, the efficiency of methods employed for converting the coarse fodders of the farm and the commercial stock foods into beef are to be considered more closely than ever before, in order that the most economical way may be selected and the necessary expenditures of money and labor reduced to a minimum.

Plan of Experiment.

In order to ascertain the efficiency and practicability of certain methods, a practical steer-feeding experiment was devised for the purpose of determining, if possible:

1. The effect of different methods of supplying drinking water.
2. The efficiency of different methods of confining fattening animals.

In order to make a satisfactory test under practical conditions, a space to accommodate three lots of steers of five each was set apart in the basement of the college barn for this trial. The basement of this barn is 65x100 feet, with the ceiling 11 feet high, and is

largely used each year for steer-feeding. Lot I occupied a pen or large box stall 20 feet long and 11.5 feet wide, which is exactly the same space that five stalls had previously occupied, including the alley at the rear of the stalls used for access, cleaning them out, etc. Lot II occupied five stalls adjoining this pen. Lot III occupied five other stalls similar to those occupied by Lot II. Lot I, or those in the box stall, were fed from a common manger and supplied with drinking water kept before them all the time in an automatic watering basin, except when the water was withheld for a short time previous to weighing periods. Lot II was also supplied with automatic watering basins similar to Lot I. Lot III was watered by turning them out for an hour or two once each day in a large yard adjoining the basement, where they were permitted to drink in common from a large watering trough. The steers in Lots I and II were not removed from the pens or stalls except as it was desired to weigh them on alternate weeks.

Animals.

The steers used in this experiment were purchased at the stockyards at Pittsburg, November 20, 1899. They were dehorned grade Shorthorn steers, raised in Northeastern Ohio, and were carefully selected as to size, age and quality, so far as appearances would indicate. While individual characteristics, which proved some animals to be somewhat more desirable feeders than others, developed as the feeding progressed, yet all would have been called good feeding steers, either at the beginning or at the close of the experiment. These steers were sorted into lots soon after purchasing and were confined in the pen and stalls until December 14, when the experiment proper was begun. It was thought best to defer beginning the experiment for a few weeks in order that the animals might become accustomed to their new surroundings, and also to give an opportunity to discard any animal that might prove objectionable.

Rations Fed.

Each lot was fed grain, consisting of six parts of corn and cob meal and one part of wheat bran by measure, in such quantities as presumably would be readily consumed. An accurate account was kept of the amount of grain consumed by each lot, but the amount fed from day to day was left to the judgment of an experienced feeder. The grain for each lot was weighed out weekly and placed in a bin. At the end of the week that remaining in the bin was weighed and deducted from the amount previously weighed out. A similar account was also kept of the hay and corn stover consumed by each lot. The individuals of each lot were weighed on alternate weeks.

The Following Table Shows the Gain of Each Steer throughout the Experiment in Periods of Two Weeks Each:

Food Consumed.

Date.	Lot I.			Lot II.			Lot III.		
	Hay.	Fodder.	Grain.	Hay.	Fodder.	Grain.	Hay.	Fodder.	Grain.
For week ending December 21, 1899.	288.0	88.0	489.0	252.0	107.5	430.0	275.0	87.0	430.0
For week ending December 28, 1899.	285.5	86.5	489.0	235.0	103.0	455.0	245.5	87.0	455.0
For week ending January 4, 1900.	265.0	100.0	496.0	256.5	109.5	480.5	240.5	88.0	480.5
For week ending January 11, 1900.	260.0	117.0	491.0	259.0	124.5	490.5	237.5	88.0	490.5
For week ending January 18, 1900.	263.5	138.0	506.0	262.5	117.5	497.0	262.5	78.5	497.0
For week ending January 25, 1900.	263.5	121.0	536.5	263.5	106.0	533.0	262.5	60.0	533.0
For week ending February 1, 1900.	263.5	124.5	557.5	263.5	112.0	557.5	262.5	74.5	557.5
For week ending February 8, 1900.	267.5	124.5	596.5	263.5	81.0	593.5	262.5	70.0	593.5
For week ending February 15, 1900.	267.5	118.0	617.0	267.5	87.0	617.0	262.5	65.5	617.0
For week ending February 22, 1900.	285.5	111.0	608.0	291.0	102.0	601.5	283.5	61.0	601.5
For week ending March 1, 1900.	287.5	104.0	590.0	297.5	108.0	585.0	286.0	63.0	585.0
For week ending March 8, 1900.	277.5	112.0	619.5	277.5	93.5	619.5	286.0	63.0	619.5
For week ending March 15, 1900.	277.5	112.0	619.5	277.5	89.5	619.5	286.0	63.0	619.5
For week ending March 22, 1900.	277.5	91.0	630.0	277.5	85.0	630.0	286.0	63.0	630.0
For week ending March 29, 1900.	323.5	.....	617.5	324.0	.....	618.5	323.5	.....	618.5
For week ending April 5, 1900.	327.25	.....	515.0	327.25	.....	497.0	327.25	.....	497.0
For week ending April 12, 1900.	327.25	.....	539.5	323.25	.....	532.0	316.25	.....	532.0
For week ending April 19, 1900.	327.25	.....	594.5	324.25	.....	576.5	300.75	.....	576.5
For week ending April 26, 1900.	327.25	.....	610.0	319.25	.....	606.0	287.25	.....	606.0
Total.	5,533.50	1,568.00	10,663.5	5,467.0	1,489.0	10,543.5	5,839.5	904.5	10,544.0

The hay consumed by the three lots was of good and uniform quality, largely timothy with a little clover. The corn stover was well cured and shredded. The grain, as explained before, consisted of corn and cob meal and wheat bran, six parts of the former to one part of the latter by measure, or 10 pounds of meal to .9 of a pound of bran. The hay and corn stover were placed in large sacks and weighed on scales and taken from the sacks and placed in the mangers as required. That remaining in the mangers was weighed back and deducted from the total amount offered them, the difference giving the amount consumed. As the refuse in many cases was inconsiderable, it was not weighed back until a quantity had accumulated in the mangers. During the whole experiment, it was observed that Lot I was eating the hay somewhat closer than the other two lots, although this difference seemed to be so slight that it was not thought best to change the quantity offered them. The total amount of refuse, however, for the lot is shown by the following tabular statement:

Amounts of Hay and Stover Offered Each Lot and the Amounts Refused.

	Hay offered.	Hay refused.	Stover offered.	Stover refused.
Lot I,	5,533.0	54.5	2,512.5	944.5
Lot II,	5,457.0	131.0	2,512.5	1,073.5
Lot III,	5,339.0	258.5	2,510.5	1,606.0

It will be observed that Lots I and II refused less hay and less stover than Lot III. In other words, the lots to which water was supplied continually consumed nearly the same amounts of coarse fodder. These two lots in this respect differed from each other much less than either differed from Lot III. Each lot was offered the same weight of hay and stover. It should be noticed, however, that the difference in the amount of coarse fodder refused, varied much more in the case of the corn stover than in the case of hay. For some reason, Lot III did not relish the corn stover so well as either of the other two lots. While this may be due somewhat to the individuality of the lot, yet the difference cannot be ascribed wholly to this without further trials. In determining the amount of stover consumed by each lot, the refuse was weighed back and carefully sampled, a moisture determination made, and the weight calculated to the original state of moisture. While it is true that the chemical

composition of the refuse would have differed somewhat from the original substance, yet the amount of dry matter consumed was accurately determined.

Weights and Gains.

The following table gives the weight of each steer and the total for each lot on alternate weeks from December 14 to April 19. It will be noticed that Lot I was slightly heavier than either Lot II or III at the beginning of the experiment, the animals of Lot I averaging $3\frac{1}{2}$ pounds apiece heavier than those of Lot III, and about 54 pounds heavier than those of Lot II.

Weight of Steers at Each Weighing.

Steer No.	December 14.	December 22.	January 11.	January 18.	February 1.	February 22.	March 1.	March 22.	April 5.	April 19.
Lot I.										
91.	1,073.0	1,100.0	1,150.0	1,192.0	1,210.0	1,232.5	1,230.0	1,270.0	1,402.5	1,450.0
92.	990.0	1,030.0	1,042.0	1,122.0	1,106.0	1,132.5	1,130.0	1,230.0	1,255.0	1,290.0
93.	895.0	960.0	967.0	975.0	985.0	990.0	1,080.0	1,117.5	1,102.5	1,150.0
94.	985.0	1,007.0	1,043.0	1,049.0	1,085.0	1,102.5	1,167.5	1,200.0	1,210.0	1,230.0
95.	1,085.0	1,130.0	1,152.5	1,152.5	1,185.0	1,217.5	1,290.0	1,322.5	1,355.5	1,402.5
Total.	5,020.0	5,207.0	5,359.0	5,459.0	5,590.0	5,675.0	6,087.5	6,250.0	6,255.5	6,502.5
Lot II.										
96.	985.0	1,027.5	1,077.5	1,097.5	1,123.5	1,132.5	1,202.5	1,235.0	1,245.0	1,292.5
97.	895.0	967.5	977.5	1,004.5	1,030.0	1,070.0	1,112.5	1,155.0	1,155.0	1,227.5
98.	927.5	977.5	1,007.0	1,013.5	1,060.0	1,095.0	1,112.5	1,127.5	1,152.5	1,202.5
99.	973.5	973.5	1,010.0	1,023.0	1,032.5	1,032.5	1,105.0	1,130.0	1,147.5	1,157.5
90.	974.5	1,027.5	1,065.0	1,100.0	1,115.0	1,130.0	1,222.5	1,250.0	1,270.0	1,310.0
Total.	4,723.0	4,922.5	5,127.0	5,250.5	5,334.0	5,600.0	5,755.0	5,907.5	5,970.0	6,220.0
Lot III.										
81.	963.5	995.5	1,022.5	1,060.0	1,072.5	1,110.0	1,150.0	1,187.5	1,194.0	1,252.5
82.	1,062.5	1,045.0	1,067.5	1,125.5	1,145.0	1,200.0	1,215.0	1,255.0	1,232.0	1,217.5
83.	967.5	1,032.5	1,065.0	1,095.0	1,125.0	1,175.0	1,184.5	1,222.5	1,255.0	1,285.0
84.	1,072.5	1,090.0	1,125.0	1,125.5	1,150.0	1,232.5	1,250.0	1,270.0	1,290.0	1,297.5
85.	967.5	977.5	1,012.5	1,060.0	1,071.0	1,105.5	1,142.5	1,152.5	1,190.0	1,200.0
Total.	4,932.5	5,142.5	5,301.0	5,471.0	5,593.5	5,826.0	5,964.0	6,087.5	6,202.0	6,402.5

The Following Table Shows the Gain of Each Steer throughout the Experiment in Periods of Two Weeks Each:
Gain of Individual Animals at Each Weighing.

Steer No.	December 14.	December 28.	January 11.	January 25.	February 8.	February 22.	March 8.	March 22.	April 5.	April 19.
Lot I.										
91	23	60	33	13	22.5	97.5	40	32.5	47.5
92	30	22	50	13	27.5	57.5	40	25	35
93	55	11	14	10	5	70	57.5	15	47.5
94	9	36.5	4.5	17	37.5	65	32.5	10	50
95	65	22.5	29.5	13	22.5	72.5	42.5	23	47
Total	187	152	180	71	115	362.5	212.5	75.5	227
Lot II.										
96	52.5	40	20	25	60	20	32.5	10	47.5
97	25	40.5	19.5	20.5	35	27.5	32.5	11	42.5
98	20	37.5	19	33.5	20	22.5	25	17.5	40
99	53	37.5	25	19	61	42.5	27.5	20	40
Total	170.5	214.5	113.5	133.5	216	155	152.5	63.5	250
Lot III.										
81	48	24	37.5	12.5	27.5	40	37.5	3.5	68.5
82	42.5	42.5	38	19.5	55	15	40	28	34.5
83	25	23	39.5	30	50	23.5	24	23	40
84	17.5	33	32.5	24.5	52.5	17.5	20	30	37.5
85	20	35	22.5	35	37.5	34	10	27.5	20
Total	151	157.5	170	122.5	222.5	130	131.5	114.5	200.5

*Weighed less than at the previous weighing.

It will be readily seen that in the case of nearly every animal, the increase in weight throughout the experiment shows considerable variation, which is no doubt largely due to the amount of water retained in the system at the time of weighing. In each case the weighing was done at 9 A. M., and after the water had been withheld for 18 hours. It will be noticed that in but two instances was there shown to be an actual loss from the previous weight. Steer No. 93 in Lot I and steer No. 81 in Lot III each, on the 5th of April, weighed less than at the previous weighing, March 22. This may be accounted for, in part at least, by the fact that after April 1, corn meal was supplied in place of corn and cob meal, the proportion of bran being the same as before. This change of feed seemed to affect the animals somewhat unfavorably for a day or so. However, they soon came back to their former appetite and consumed their rations with the usual relish.

The following table gives the gain of each individual lot:

Steer No.	First weighing.	Last weighing.	Total gain, lbs.	Gain, per cent.	Gain per day, lbs.
Lot I.					
91,	1,072.0	1,450.0	378.0	35.26	3.09
92,	990.0	1,290.0	300.0	30.30	2.33
93,	895.0	1,150.0	255.0	28.49	1.02
94,	998.0	1,280.0	282.0	28.25	2.08
95,	1,065.0	1,402.5	337.5	31.69	2.63
Total,	5,020.0	6,553.5	1,533.5	30.53	12.17
Lot II.					
86,	935.0	1,292.5	357.5	31.22	2.44
87,	892.5	1,227.5	335.0	37.53	2.98
88,	927.5	1,208.5	281.0	29.95	1.18
89,	972.5	1,157.5	185.0	23.11	1.71
90,	974.5	1,310.0	335.5	34.43	2.98
Total,	4,752.0	6,220.0	1,468.0	30.69	11.65
Lot III.					
81,	952.5	1,252.5	300.0	31.49	2.33
82,	1,002.5	1,317.5	315.0	31.42	2.50
83,	997.5	1,295.0	297.0	29.77	2.36
84,	1,072.5	1,337.5	265.0	24.71	2.10
85,	967.5	1,200.0	232.5	25.33	1.92
Total,	4,962.5	6,402.5	1,440.0	28.50	11.27

From the above table it will be readily seen that Lot I made the greatest gain per day, although the gain in per cent. over the original weight did not quite equal that of Lot II. In Lot I, every animal gained more than two pounds per day, and one equaled or exceeded three pounds. In each of the other two lots there was at least one animal whose daily average gain was below two pounds per day during the whole time of the experiment.

The following table gives the amount of food consumed by each lot per pound of gain in live weight:

Food Consumed.
Per Pound Gain in Live Weight.

	Hay	Stover.	Grain.
Lot I,	3.61	1.03	6.96
Lot II,	3.72	.98	7.13
Lot III,	3.76	.64	7.43

There was not very much difference in the amount of hay consumed by the three lots per pound of gain in live weight, but the corn stover and grain varied considerably more. Lot III refused to eat as much corn stover as either Lot I or Lot II, but consumed about seven per cent. more grain for the same gain in live weight than Lot I.

It has been given as a reason for not feeding several steers in a pen that there was more danger of being a great variation in the gain than where stall feeding is practiced; in other words, that there would be more underlings that would not receive their proportion of food and would not, therefore, make so good gains as if they were protected from their larger and stronger companions. While a bunch of five steers is not sufficiently large to show whether this would be a serious objection, yet from the data secured from this trial, the indications are that there is practically no difference in regard to this point. At any rate, the gain of the individual animals in Lot I is quite as uniform as in Lots II and III.

Labor Required.

The following tabular statement indicates the amount of time in hours required for one man to care for each lot during the entire time of the trial:

Time of One Man Required for Attendance.

	Hours.	Percentage of Lot III.
Lot I,	93.66	76.0
Lot II,	113.33	92.0
Lot III,	123.26	

It will be noticed that Lot I received much less attention than either Lots II or III. In other words, it was found that one man could attend more animals in pens than would be possible where each individual was kept in a stall. It required much less time to clean out the stables, and it also took less time to properly litter or distribute the bedding. The stables were cleaned daily for Lots II and III, but from Lot I the manure was only taken out a few times during the whole experiment. In each case the same amount of litter was given each lot. Early in the experiment it was found that the animals in Lot I were keeping very much cleaner than the animals of Lots II and III. As all the animals were kept clean by the use of the brush and curry-comb, a considerable less time was necessary for this purpose in the case of Lot I than either of the other two lots.

Conclusions.

So far as any conclusions are warranted from a single experiment with a few animals, the above results would seem to indicate that dehorned steers can be fed in pens, in the manner practiced with Lot I, with at least as satisfactory results as regards gain as when handled in the more common way, while there is a very considerable saving in the amount of work required to properly care for them.

The self-watering device also saved considerable work and possibly effected some economy in the amount of grain consumed per pound of gain, although the unavoidable differences between the lots render this conclusion far from certain.

A COURSE IN NATURE STUDY FOR USE IN THE PUBLIC SCHOOLS.

BY MISS LOUISE MILLER, *Ithaca, N. Y.*

FIRST GRADE.

SEPTEMBER.

PLANTS.

Compare growth of twigs on different trees—maple, horse-chestnut, poplar, spruce.

Relation of insects to leaves—used as nests, for food, for depositories for eggs, not disturbed.

Fruits.—Classification as to color and taste; reason for color and taste.

ANIMALS.

Migration of birds. Study cat and dog. Compare coats as to texture, color, distribution, warmth and protection.

ELEMENTARY GEOGRAPHY.

Construct a magnetic needle to determine directions.

Daily record of day, date, frost or dew, direction of wind, clouds or fogs, rain, temperature.

Locate places in the horizon where the sun rises and sets. Position of sun at noon; morning and evening star.

MINERALS.

Make collections of pebbles. Classify as to color, form, smoothness, weight, etc. Examine coarse and fine sand. Relate to smoothness of pebbles, and effects of water.

NOTE.—In the study of trees, observations should be confined to a few throughout the year. The shape, bark, wood, leaves, blossoms, fruit cocoons, should be studied and comparisons made. The life infesting the tree should be noted, and, if possible, reasons assigned.

Place list of different kinds of birds observed by pupils during summer in a conspicuous place on the board, also list of those observed during first weeks of school. Relate migration of birds to Weather Record, noting effect of temperature upon insect life, growth, bud scars and leaf scars. Relate structure and migration to food getting; robin and earthworm; woodpecker and grub; quail and seeds.

Construct magnetic needle by magnetizing end of a needle with opposite poles of a magnet, inserting through center of small cork, and suspending by silk thread.

Suspend a prism in a window where the sun may strike it, forming a spectrum.

Compare color of flowers, leaves, fruits, pebbles with spectrum, noting prevailing color.

Much attention should be given to sense-training. Children should be led to detect form and texture by touch alone, perfume by smell, sound by hearing, flavors by tasting, weight by the muscular sense, different fruits, leaves, flowers, minerals, birds, insects by sight.

OCTOBER.

PLANTS.

Buds for next year's growth; color of bark, growth of wood; hardness of bark and wood.

Leaves.—Effect of frost, color of falling leaves, leaf-scars. Seeds.—Distribution by wind, bursting pods. Protective coloration of seeds.

ANIMALS.

Disappearance of birds, insects and animals. Relate covering to disappearance. Compare movements of cat and dog with birds, insects and other animals.

ELEMENTARY GEOGRAPHY.

Compare frost, dew, winds, clouds, fogs, rain and temperature with September.

Change in rising and setting sun; position of sun at noon. Change of length of day and night.

MINERALS.

Classify as to physical properties sandstone and limestone. Compare sand and clay. Relate to disappearance of frogs, turtles, snakes, etc.

NOTE.—Children should be led to see that destiny of trees does not depend alone upon the production of its seeds, but that much of its energy is devoted to growth. Compare number of buds formed by different trees and relate to its development. Relate falling leaves to disappearance of sap into roots, structure of leaves to distribution, etc.

Fruits whose germs are destroyed when eaten, are usually of a dull color when ready for distribution—nuts; those whose germs are not so destroyed, assume a brilliant color; luscious taste and fragrant odor—cherries, peaches, grapes.

Relate frost to disappearance of birds and insects, winds to distribution of seeds, change of position of sun to change in temperature and its effects upon life. In primary grades pupils should be forming geographical concepts and they can do so most effectually by coming in contact with things.

NOVEMBER.**PLANTS.**

Preparation of twigs for winter—thickened bark, scales on buds, etc.

ANIMALS.

Preparation of animal life for winter. Compare covering of cat, dog and sheep in their preparation for winter. Use of wool for clothing.

ELEMENTARY GEOGRAPHY.

Prevailing winds cold or warm, wet or dry. Clouds higher or lower than in September and October. Examine frost crystals.

Compare rising, setting and position of sun at noon with September. Rising of new, full and waning moon.

MINERALS.

Examine granite and marble. Compare size of crystals. When are snow crystals large?

NOTE.—Compare preparation of twigs, thickening of bark, number and character of scales on bud, varnish and protection of leaves inside of bud. Relate change in temperature to preparation of animals for winter. Relate change of position of sun to change of temperature.

DECEMBER.**PLANTS.**

Effect of frost upon plant life; protection and use. Any germination.

ANIMALS.

Compare dog, cat, sheep, horse and cow as to movements, means of getting food, means of protection, use to man.

ELEMENTARY GEOGRAPHY.

Examine snow-flakes. Frost and snow protection to life.

Compare rising, setting and position of sun at noon with September.

MINERALS.

Compare structure of granite, marble, limestone, and sandstone.

NOTE.—Relate length of day to frost and its effects. Spruce trees should be studied in relation to Christmas. Difference between evergreen and deciduous trees, leaves and needles, fruit and cones, bark, wood, etc. Relate structure of animals to environment. Compare manner of putting down the feet, length and structure of limbs, cushions, claws, hoofs, etc. Relate to manner of getting food. Relate snow flakes and frost, dew and rain, to change in temperature. Note effect of frost upon soils. Relate to plants and seeds and hibernating animals.

JANUARY.

PLANTS

Effect of warm days upon plants. Enemies of buds—birds and frost; protection of buds. Sap in trees.

ANIMALS.

Compare food of January and June. Compare teeth of dog and cat, sheep, cow and horse with human teeth and relate to kinds of food.

ELEMENTARY GEOGRAPHY.

Compare number of rainy or snowy days with December. Increase of day; rising and setting sun. Compare with November.

MINERALS.

Compare physical characteristics of granite, marble, sandstone, limestone and slate.

NOTE.—Of what advantage or disadvantage, are warm days in January to plants? When and why are buds used by birds as food? Examine twigs of maple, horse-chestnut, and spruce. Note buds destroyed by birds, wind, or killed by frost. Compare hibernating and non-hibernating animals as to covering, structure, manner of getting food, etc.—turtle, cat, dog or bird. Place hibernating animals in a box of moist earth and permit pupils to observe them disappear.

FEBRUARY.

PLANTS.

Determine location of frozen buds on twigs; number found, kind, number killed and number alive.

ANIMALS.

Manner in which dog, cat, sheep, horse and cow take their food. Compare prehensile organs with man's.

ELEMENTARY GEOGRAPHY.

Increased or decreased temperature since December. Compare January and February. Prevailing wind—cold or warm.

Compare length of day and night with previous months. Note sunrise and sunset.

MINERALS.

Compare different kinds of coal in color, weight, softness, hardness, etc.

NOTE.—Observe the amount of work done by different trees in preparation for winter. Relate to effectiveness. The horse-chestnut has a few well protected buds prepared; others many, but not so well protected. Moral lesson.

Function of leaves, assimilation of food.

Compare this year's growth of horse-chestnut, maple, and spruce as to number, size, shape, texture, etc. Reason.

Compare perfection of jaws of animals with length of jaw.

MARCH.**PLANTS.**

Study tree—environment, beauty, form, leaves, blossoms, etc.

ANIMALS.

Begin Natural History Calendar—observation, day, date, by whom, remarks. Watch for the first appearance of birds.

ELEMENTARY GEOGRAPHY.

Change in cloudiness, rainfall. Compare with September and December.

Compare length of day and night.

MINERALS.

Compare granite, limestone, marble, sandstone and coal, as to color, texture, weight, tenacity.

NOTE.—Effect of location of a tree near house, other trees, in open space. Observe trunk and branching of maple, horse-chestnut and spruce. Note beauty, grace, symmetry, form. Press specimens of leaves from different kinds of maple trees, also preserve fruit of trees.

APRIL.**PLANTS.**

Germination of seeds—bean, pea, corn, wheat.

ANIMALS.

Appearance of moths and butterflies. Change in covering of cat, dog, sheep. Compare eyes. Imitate sounds made by cat, dog and sheep.

ELEMENTARY GEOGRAPHY.

Observation of temperature, direction of wind, number of foggy and clear days. Compare with other months.

Relate lengthening day to change in movement of sun; to shadow at noon. Compare with previous months.

MINERALS.

Examine sand, gravel, loam and clay. Value of earth in relation to plant life.

NOTE.—Examine dry and soaked peas, beans, corn, and wheat. Note coats, scars and opening near the scar.

In all work in plant life, as in every other study, thought should first be acquired, and then expression.

Collect larvae during the fall, permit pupils to see and note date of spinning cocoons, and appearance of insects.

Animals and plants should be studied in life cycles.

Relate movement of sun to temperature and its effect upon life.

Encourage pupils to plant seeds at home and care for the plants.

MAY.**PLANTS.**

Flowers; buds, color, perfume, honey; pollen distributed by insects, wind; leaves—blade, parallel and netted veined.

ANIMALS.

Observe habits of common birds, location and kinds of nests, protective coloration of feathers.

ELEMENTARY GEOGRAPHY.

Compare clear, cloudy and rainy days with April.

Continued observation of sun and shadow; relate to temperature and life.

MINERALS.

Study of soils.

NOTE.—In teaching flowers, technicalities should be avoided. Emphasize color, form, marking, perfume, honey. Influences which produced the flower—earth, air, rain, sun, insects, birds.

Relate soils to food for plants.

JUNE.

PLANTS.

Continued study of flowers and leaves. Parts of flowers—calyx, sepals, corolla, petals, stamens, carpel. Plants as wholes.

ANIMALS.

Birds—hatching of young, care of young, food. Compare young of cats, dogs, birds, butterflies, in covering, ability to help themselves, food, movements, etc.

ELEMENTARY GEOGRAPHY.

Thunderstorms, hailstones. Destructive effects of each. Compare length of day and night.

NOTE.—Children can readily distinguish parts of fruit blossoms. The dandelion should be studied as a whole.

The sparrow, robin, woodpecker and criole are best adapted to this grade.

SECOND GRADE.

SEPTEMBER.

PLANTS.

Compare growth of twigs of different trees, of different years. Oak, elm, pine.

Relation of insects to leaves as food, as nests, as depositories for eggs. Prevailing color in same leaves. Plants storing food.

ANIMALS.

Migration of birds. Compare coats of squirrel and rabbit as to texture, color, distribution, warmth, protection. Habits of grasshoppers. Observe caterpillars spin cocoons. Prepare an ants' nest. See fifth grade.

MINERALS.

Visit a stream; forces acting upon pebbles; formation of marbles.

ELEMENTARY GEOGRAPHY.

Daily record of day, date, frost or dew, direction of wind, clouds or fogs, rainfall, temperature. Moon's phases, rising and setting sun.

Locate places in the horizon where the sun rises and sets.

NOTE.—Weather Records should be kept from year to year and differences in growth of different years should be referred to variations in atmospheric conditions.

Observations of life infesting trees continued.

Record of migration of birds same as Grade I.

Study squirrel and rabbit as to shape of body, head, ears, mouth, legs and paws.

Oak, pine, turnips, parsnips store food for animals.

Remove an ant hill to a glass fruit jar and cover with brown paper. Food—sugar. By removing the paper, halls, galleries, and habits may be observed.

Place larvae of insects in an empty chalk-box containing leaves on which they feed. Slide piece of glass in the top that the feeding and spinning cocoons may be observed. Record dates.

OCTOBER.**PLANTS.**

Preparation of twigs for winter; disappearance of sap, drying leaves; falling leaves, scars; location and arrangements of buds; structure of seed for distribution—wings, pappus, hooks. Color of seeds.

ANIMALS.

Habits of squirrel, of rabbit, as to storing food—how, where, kind and quantity.

MINERALS.

Formation of pebbles. Compare as to transparent, translucent and opaque.

ELEMENTARY GEOGRAPHY.

Effect of prevailing wind upon clear, cloudy, wet and dry weather. Direction of heaviest rains. Compare with September.

Compare October and September as to rising and setting sun, length of day and night.

Constant position of North Star, revolution of Great Bear around it; pointers in Great Bear.

NOTE.—The wind distributed seeds are supplied with wings and pappus, usually found on tall trees accessible to wind. Seeds supplied with hooks grow on low bushes so they can attach themselves to passing animals. Before seeds are ripe they are enclosed in green pods or shucks, color of leaves of plants. When ripe, they are brown like earth upon which they fall. Compare leaf scars of horse-chestnut and butternut.

In studying squirrel and rabbit, secure a live specimen if possible. Pupils enjoy the action, and the results are more effective. Nothing engenders a love for animals as care of them. Collect nuts for food of squirrels. Observe manner of eating, manner of opening shell. Do you find shells in the woods which have been opened by squirrels?

Place fragments of rock in bottle of water and shake frequently. Place pebbles of different sizes in bottle and shake frequently. Which wears away more quickly?

NOVEMBER.

PLANTS.

Dormant condition of plant life: annuals—those producing many seeds; biennials—those storing nourishment; perennials—those producing buds and seeds.

ANIMALS.

Squirrel and rabbit—manner of eating. Food of squirrel stored by itself; food of rabbit stored by plants.

MINERALS.

Collect and classify metals and minerals—very soft, soft, hard and very hard.

ELEMENTARY GEOGRAPHY.

Frost or dew more common? Effect of wind, and clear or cloudy night upon formation of frost or dew.

Compare course of sun with September and October. Effect upon length of day and night; temperature.

NOTE.—Relate effect of shortening of days upon temperature and plant life.

Compare milkweed, turnip and tree. Destiny of annuals depends entirely upon production of seed. Count seeds in pods of one milkweed plant. Trace life history of biennial—appearance of root and stem of first year; root, stem, leaves, flowers, fruit of second year. Count seeds. Show relation between number of seeds prepared and number of buds formed by perennials.

Relate minerals and metals to material stored away in the ground for man's use.

DECEMBER.

PLANTS.

Effect of frost upon twigs, buds, and seeds.

ANIMALS.

Compare development of limbs in quadrupeds and bipeds; position of body in each; use of upper limbs. Compare squirrel and rabbit with cat and dog.

MINERALS.

Effect of thawing and freezing upon roots of plants. Power of granite, limestone, sandstone, coal, sand, clay, iron ore, copper ore to absorb and retain moisture.

ELEMENTARY GEOGRAPHY.

Increased or decreased cloudiness, rainfall; wind more or less variable; wind preceding rain or accompanying clearing weather.

Relation of line showing apparent paths of sun since September. Winter solstice.

NOTE.—Pupils should have definite idea as to rising and setting of sun, its position at noon in December. From personal observation difference between animal and plant life of June and December carefully noted.

Development of most parts of animal organism is for the purpose of securing food. Erect position of body is proportioned to development of fore-legs as prehensile organs.

The work on minerals is for the purpose of showing the value of each for building purposes. Weigh in air, immerse in water and weigh again while wet. Difference in weight shows absorptive power. Effect of frost—cracking rock.

JANUARY.**PLANTS.**

Dormant condition of plants.

ANIMALS.

Winter condition of animal life. Compare teeth of rabbit and squirrel with dog and cat. Compare teeth and food of each with man.

MINERALS.

Recognize different kinds of iron ore by color, hardness, crystals, weight. Relate to steel and sharp cutting instruments and tools.

ELEMENTARY GEOGRAPHY.

Month of greatest change in temperature. Compare prevailing winds with previous months. Effect of temperature upon rainfall.

Note sun at noon; apparent movement, effect upon day and night.

NOTE.—Effect of frost upon germination. Snow a warm covering. A poor conductor of heat, excludes cold and prevents radiation of heat. Relate prevailing winds to frost and snow.

Pupils should be led to see that animals use their claws for digging, and their teeth for cutting and tearing their food, but man has too many demands for his physical organism and is forced to construct tools for his use.

FEBRUARY.**PLANTS.**

Winter condition of trees.

ANIMALS.

Compare structure of head, hand and teeth of different animals; effect of development of one upon the other. Compare jaw, teeth and hand of squirrel, rabbit and man.

MINERALS.

Recognize different kinds of copper ore by color, hardness, crystals and weight. Uses.

ELEMENTARY GEOGRAPHY.

Compare snowfall, rainfall and fogs with previous months.

Note lengthening day; morning or evening longer. Movement of sun on horizon.

NOTE.—Shape of tree, angle of branching, development of tree.

Compare head of cat or dog, sheep or cow, rabbit or squirrel, and human teeth.

Relation of lengthening of day to enlivening of bark and swelling of buds.

Use of copper for wires; value to man. Man's superiority over other animals in his use of tools.

MARCH.**PLANTS.**

First awakening of plant life; select a tree for accurate and systematic study; difference between a tree and shrub.

ANIMALS.

Return of birds, appearance of insects. Natural History Calendar. Protective coloration of squirrel and rabbit.

MINERALS.

Study soils in relation to plant life; power of different kinds of soil to absorb and retain moisture.

ELEMENTARY GEOGRAPHY.

Highest and lowest temperature during the month; character and amount of cloudiness in March, December and September.

Compare number of rainy days, in autumn, winter and spring.

Vernal equinox; seasons of year since autumnal equinox; rising and setting sun; length of shadow at noon.

NOTE.—Observations should be recorded on Natural History Calendar. Foster an interest in Nature, and gradual unfolding of life.

Select a tree convenient for constant observation. Measure diameter, height of branching, etc. Secure transverse and longitudinal sections of wood of the same kind of tree. Note carefully color, hardness, softness, toughness of bark of different years' growth. Location and arrangement of buds. Study color, size, covering, protection, etc. Record first appearance of leaves, flowers and fruit. Study continued to end of year.

Nesting habits of birds; location of nests, material used. Birds of dull color have open nests,—brilliant colors concealed nests.

Relate color of squirrel to bark of tree, color of rabbit to ground and weeds. Why are black squirrels disappearing?

Study meadow-lark, owl, duck, snipe, tanager, duck; relation to color, structure to environment and manner of getting food.

APRIL.

PLANTS.

Observe germination of seeds, different parts of seed; ratio of leaf buds and flower buds.

ANIMALS.

Earthworm—food, manner of moving, value to mankind. Relate earthworm to preparation of soil for plants. Compare earthworm and squirrel and rabbit, as to appearance, senses, movements, manner of getting food.

MINERALS.

Power of different soils to absorb and retain heat. Relate to plant life.

ELEMENTARY GEOGRAPHY.

Wind that accompanies wet, dry, clear, cloudy or foggy weather. Difference between April and winter rains.

Compare course of sun with December, reason for shortening of shadow; relation of length of shadow to temperature.

NOTE.—Measure a gill of corn, wheat, beans and peas; soak twenty-four hours. Measure. Which absorb water? Let each pupil examine a dry and soaked seed. Plant seed in different kinds of soil—clay, sand and loam. Place in light, shade, and dark to detect influence of light upon plant. Record time of planting, first appearance above ground, dropping of exhausted cotyledons.

Seed.	Bean.	Pea.	Corn.	Wheat.
Planted.	April.			
Depth.	1 inch.			
Above ground.	April.			
Cotyledons.	Above.	Below.	Below.	Below.
Leaves.	Netted.	Netted.	Parallel.	Parallel.
Leaves.	Compound.	Compound.	Simple.	Simple.
Position.	Alternate.	Alternate.	Alternate.	Alternate.
Margins.	Entire.	Entire.	Entire.	Entire.
Shapes.				

To compare gradual development of plant, pull up, press, and mount specimens on alternate days, showing development of different parts from seed to seed. Development may also be observed by being placed in bottles of alcohol. Carefully date each specimen. Plant acorns in yard.

Fill a large sponge with flaxseed and place in a shallow dish filled with water. Keep moist.

Mark off a yard square and observe the work of earthworms. Each morning, carefully collect castings and measure. Some idea of amount of work being done in renewing and fertilizing soil. Study structure, food, habits, senses; adaptation of structure to environment. Pupils should be led to see that each plant and animal is adapted to perform its function in the economy of nature.

Relate April showers to increasing temperature—greater heat, greater evaporation, consequently greater condensation.

MAY.

PLANTS.

Reason for early appearance of wild flowers; food; protection and color of spring flowers; advantage of color; unfolding of buds. Venation.

ANIMALS.

Study snails—land and water snails; difference in structure, shells, food, etc. Compare with earthworm, as to senses, manner of moving, muscular action, food protections. Compare snail shells with other shells.

MINERALS.

Examine soils carefully. Origin of soil—decayed vegetation and disintegration of rock. Relate qualities of soil to vegetation.

ELEMENTARY GEOGRAPHY.

Number of frosts or dews; compare with November; temperature of nights; direction of prevailing wind. Relation of wind to rainfall.

Lengthening of days; changing course of sun and effects upon all life.

NOTE.—Compare roots of spring beauty, crow-foot, water-cress, Indian-turnip, tulip, crocus. Relate food stored by plants in roots to nourishment provided by

cotyledons. Rapid growth due to food already assimilated.* Color to attract insects and effect fertilization of flower. Relate lengthening days and increasing temperature to appearance of wild flowers and abundance of pond life. Relate falling leaves to formation of vegetable mould. Effect of rain upon surface of ground to disintegration of rocks.

Note difference in growth of plants grown in sand and loam. Reason.

Make a collection of spring flowers.

JUNE.

PLANTS.

Continue study of flowers. Arrangement of leaves on twigs; simple and compound, netted and parallel veined.

ANIMALS.

Insects; compare ants, spiders, flies and beetles; likenesses and differences in habits. Usefulness.

MINERALS.

Compare soil used as homes by ants, and earthworms. Effect of each upon soil.

Elementary geography.

NOTE.—Parts of leaves—petiole, blade, midrib, veins, veinlets, base, apex, margin. Distinguish between simple, palmately and pinnately compound. Press and mount specimens of all species of oak leaves. Make a collection of acorns.

Recognize linear, lanceolate, oblong, elliptical, and oval forms. Bases—heart-shaped and shield-shaped. Apex—acute and obtuse. Margins—entire, toothed, notched.

Function of veins—to carry sap; blade—to absorb moisture and carbon dioxide.

Flower: Calyx—sepals, corolla—petals, stamens—filament, anther and pollen; carpel—ovary, ovules, style, stigma.

Study syringa and pansy.

Parts of insects: head—eyes, antennae, mouth-parts. Compare life history of each—egg, larva, pupa, imago; community life of ants. Habits of spiders and beetles. Encourage habit of personal observation on part of pupils.

The study of the ant is suggested for this grade, being accessible and harmless. The habits, home making and community life can better be observed in a nest than in the ground; food getting and storing by watching them in the grass and on sidewalks. Study members of the household:—queen, workers, warriors, etc. Note care of young, intelligence, communication; battles, excursions for food, etc.

*Compare annual and perennial rootstalks.

THIRD GRADE.

SEPTEMBER.

PLANTS.

Relate growth of twigs on north, south, east and west side of trees to symmetrical development of tree. Study pine—type of excurrent tree, fruit tree—type of deliquescent tree. Note color of leaves on different parts of tree. Relate coloration of seed to distribution by animals as food, by animals in covering, by wind.

ANIMALS.

Distinguish between vertebrated, mollusious, articulated and radiated animals. Food, homes, and means of protection. Use familiar examples of each—bird or fish, oyster or clam, insects, starfish, etc. Review and classify animals previously studied.

MINERALS.

Compare sandstone and limestone. Sedimentary rock. Classify rocks in your neighborhood.

ELEMENTARY GEOGRAPHY.

Evaporation; dew, frost, rain.

Daily record of day, date, direction of wind, clouds or fogs, rainfall, temperature, barometer, moon's phases, morning and evening stars.

Rotation and revolution of the earth; inclination of axis; day and night; change of seasons; Autumnal Equinox; Little Bear, Jupiter and Venus.

NOTE.—Emphasize geology in this grade, and do as much field work as possible. Take advantage of any natural features in the vicinity of the school house.

Forces at work: air, water, wind, frost; building coasts; crumbling cliff; deepening gulch; filling marsh.

Note erosion and sedimentation in school yard and street. Always relate physical characteristics of minerals and soils to erosion and change in earth surface.

Relate lime in solution in water to life in water, and beds of limestone.

OCTOBER.

PLANTS.

Compare new and old growth of twigs as to color, hardness, softness, texture; seeds growing on twigs—wings, hard, round, shell; near ground—pappus, hooks and prickles.

ANIMALS.

Relate color of animals to their environment. Protection and attractive coloration. Frogs, toads, grasshoppers, quail, wild cat, polar bear, leopard, tiger, etc. Relate to food-getting.

MINERALS.

Stratified and unstratified rock; limestone, sandstone, slate, granite and marble.

ELEMENTARY GEOGRAPHY.

Condensation—formation of rain, snow, hail, frost, dew, clouds. History of a raindrop.

Different forms of clouds: Cirrus, Cumulus, Stratus, Nimbus. Elevation of each.

Time and place of rising of new, full and waning moon. Effect of day and night upon life.

Movements of Jupiter and Venus.

NOTE.—Powder gray sandstone, put into a jar of water, shake contents and allow to settle. Next day drop powdered red-sandstone and continue for several days. Result—stratified material. Drop sand, gravel, loam, clay into a jar of water. Shake and allow to settle. Result—stratified, assorted material. Dissolve lime in water and allow to settle.

NOVEMBER.

PLANTS.

Mode of distribution of seeds of animals, biennials, and perennials. Effect of frost upon twigs, scaly and naked buds.

Preparation of plants for winter.

ANIMALS.

Preparation of animals for winter—thickening of coat, preparation of homes and storing food. Relation of structure of animals to manner of getting food; land and water animals.

MINERALS.

Life history of a pebble—part of cliff or rock; acted upon by air, water and frost. Compare sandstone, granite and limestone pebbles—as to color, form, smoothness, hardness, etc.

ELEMENTARY GEOGRAPHY.

Compare rainfall with October and September. Forms of clouds most common—high or low. Relation of temperature to cloudiness and rain; relation of cloudiness to rainfall.

Compare variation of shadow of October, September, and November. When greatest? When least?

NOTE.—No work can be more conducive to the cultivation of the imagination than to trace the history of a pebble. Moral lesson: contact with different conditions in wearing off the rough edges. Difference in color and texture show different origin; bands and faults show varied experience in life history. Physical forces acting.

DECEMBER.**PLANTS.**

Examination of horse-chestnut, maple and fruit trees. Compare growth, bark, scars, number of arrangement and covering of buds formed. Probable fate of buds.

ANIMALS.

Distinguish between vertebrated animals; mammals, birds, fishes, reptiles, amphibians.

MINERALS.

Action of acids upon sandstone, limestone, marble, granite, mica, quartz, coral, shell. Relate to formation of caves—chemical forces acting.

ELEMENTARY GEOGRAPHY.

Influence of storm upon barometer. Effect upon temperature.

Winter Solstice. Compare shadow of September 21 and December 21.

NOTE.—Place small piece of rock in test-tube and note effect of dilute sulphuric or hydrochloric acid upon it. Result. Note which one dissolves most readily. Beds of rock best adapted to formation of acids. Effect of water, holding acid in solution, upon lime rock. Why was it possible for Mammoth Cave to have been formed where it is? Why is the Blue Grass region so fertile?

Compare physical and chemical forces acting.

JANUARY.

PLANTS.

Dormant condition of plant life; death of all annuals; roots of biennials; stems or perennials.

ANIMALS.

Compare teeth, hoofs, and claws of rodents, carnivorous, herbivorous, and omnivorous animals; teeth—crown, fangs, enamel, incisors, canine, bicuspid, molars.

MINERALS.

Fossil animals, teeth, shells, plants, leaves, etc. Identify fossil animals and plants with living things. Conditions of fossilization. Change in earth conditions. Account for fossil ferns in coal.

ELEMENTARY GEOGRAPHY.

Variation of temperature before, during and after a storm; variation of barometer and thermometer.

Effect of sun's position on temperature. When do shadows correspond and differ most?

NOTE.—Relate fossil animals and plants to kind and quantity of life extant in remote ages. Compare similar life of the present day.

Pupils should be encouraged to make collections of fossil plants and animals and to look for them in limestone used for building purposes. At first it is sufficient to be able to distinguish them by sight.

FEBRUARY.

PLANTS.

Examine trees for frozen buds and twigs; roots and blades of grasses; trunks of trees for mosses.

ANIMALS.

Begin study of birds; environment—earth, air, water. Relate structure to environment. Aerial birds—long, slender bodies, powerful wings; terrestrial birds—large bodies, strong feet, small wings; aquatic birds—boat-shaped bodies, short legs, webbed feet, or long legs, long neck, long bill; eagle, chicken, duck or crane.

MINERALS.

Continue study of fossil animals. Change of structure in earth's crust; erosion, sedimentation, upheaval, denudation.

Life history of a fossil fern.

ELEMENTARY GEOGRAPHY.

Compare temperature, barometer, rainfall, fogs, clouds, wind with previous months; with months whose days are about the same length.

When do shadows correspond and differ most.

NOTE.—Compare fossil ferns with ferns growing at present. Study a coal mine. Life history of a piece of coal.

MARCH.**PLANTS.**

Begin close and comparative study of horse-chestnut, maple and fruit trees. Environments, shape, symmetry.

ANIMALS.

Continue study of birds. Manner of getting food, etc. Birds of prey, climbers, perchers, scratchers, waders, swimmers and divers.

MINERALS.

Recognize different kinds of iron ore and coal by color, weight, crystals and external appearance.

ELEMENTARY GEOGRAPHY.

Compare March with September. Note frost, or dew, wind, clouds, fogs, rainfall, temperature, barometer, sunrise and sunset.

Relative position of earth on September 21 and March 21.

NOTE.—In this grade children should get some general ideas of silvi-culture and forestry, and economic importance of trees and forest protection. Nuts as a food product.

APRIL.**PLANTS.**

Germination of seeds; continue tree study.

ANIMALS.

Continue study of birds; parts of bird—head, body, wings and legs. Nesting habits of birds. Relate color to nesting habits.

MINERALS.

Reduction of iron. Compare pig iron, cast iron, wrought iron and steel. Uses of iron. Iron as a factor in civilization.

ELEMENTARY GEOGRAPHY.

Compare April showers with winter rains; temperature of nights and days. Explain differences of character and position of clouds in winter and spring.

Compare variation of shadow with November.

NOTE.—Germinate peach, apple, horse-chestnut, maple and pine seeds. Relate protection of the embryo to use of fruits for food.

Compare structure of birds' nests with the homes of other animals, and man.

Visit a rolling mill if possible and learn the reduction of iron from observation.

MAY.**PLANTS.**

Parts of flower—floral envelope and essential organs. Compare fruit, blossoms, maple and horse-chestnut.

ANIMALS.

Continue study of birds; hatching of young; care of young; manner of walking, of movement, of flight. Relate nesting habits, and food of birds to trees.

MINERALS.

Recognize different kinds of iron ore. Mining interests of Pennsylvania.

ELEMENTARY GEOGRAPHY.

Influence of April showers upon May flowers. Wind that accompanies highest and lowest temperatures.

Compare long twilights of summer with short twilights of winter.

NOTE.—Pupils should be led to see that the energy of the plant is directed toward maturing seeds; that each part of the plant has its own work to do; that color, form, texture, perfume, are modifications of effect cross-fertilization of the flowers.

JUNE.**PLANTS.**

Continue study of flowers; plan of flowers. Distinguish between imperfect and incomplete flowers. Continue tree study. Leaves: simple and compound, parallel and netted veined.

ANIMALS.

Study bees in relation to fertilization of flowers. Continue study of birds. Feathers: shaft, vane, quill, barbs, barbules. Compare feathers on different parts of body. Relate to food getting. Eagle's wing, feathers of an owl, tail of a woodpecker, body of a duck, wings of an ostrich.

MINERALS,

Mining of coal. Drilling of oil wells. Importance of petroleum.

ELEMENTARY GEOGRAPHY.

Which month had largest number of clear days, rainy days; which coldest month; which warmest. Extremes of temperature.

Summer Solstice. Relative position of earth and sun June 21. Compare sunrise, sunset and sun at noon with September, December and March.

NOTE.—The study of bees is a very interesting subject. Their community life, habits, food, keen sense perception furnish a fine opportunity for investigation.

Pupils should be encouraged to imitate the calls of the birds, and note manner of communication.

Influence of iron and coal upon civilization.

FOURTH GRADE.

SEPTEMBER.**PLANTS.**

Each pupil select tree for systematic study throughout the year. Protective coloration of leaves and fruit; development of flowers into fruit; form of fruit—fleshy, stone, dry.

Lower forms of plant life—algae, fungi, and lichens.

ANIMALS.

Swamp life. Observe larval stage of insects. Compare clam and oyster, as to food, habits, structure, movements, protection, nature of shell.

MINERALS.

Character of soil formed in swamps and marshes. Relate to peat bogs.

ELEMENTARY GEOGRAPHY.

Magnetic needle; compass; construction and use. Relate to iron and steel.

Dissolve, salt, alum, lime in water. Relate solution to erosion of rock, and lime in solution to shells and bones of animals.

Daily record of day, date, frost or dew, clouds or fogs, rainfall, temperature, barometer, sunrise, sunset, morning star, evening star, moon's phases, moonrise, moonset.

Measure slant of sun's rays on shadow stick. Autumnal Equinox, September 21; path of sun, Mars, Mercury.

NOTE.—Systematic study for trees following outline for tree study. Environment, shape, parts.

Observe fallen leaves exposed to the air, and those in streams or ponds.

Prepare a self-sustaining aquarium, showing the co-operation of animal and plant life.

In this grade pupils should get a glimpse of the evolution of plants and animals and their interdependence.

OCTOBER.**PLANTS.**

Protection of unripe nuts; distribution of nuts and seeds; different appliances for distribution. Make collections of seeds in their pods. Storing of seeds by insects and animals.

ANIMALS.

Careful and systematic study of insects hibernating and non-hibernating. Habits of turtle and crayfish. Animals that store food and those that do not.

MINERALS.

Study coal. Collect carbon from burning candle, sugar, paper, wood, meat, wool and coal. Relate carbon to plants and animals.

ELEMENTARY GEOGRAPHY.

Influence of mountain ranges and large bodies of water upon rainfall and temperature.

Compare variation of shadow with September. Compare shortening of days in morning and evening. Change in position of constellations and stars.

NOTE.—Pupils should be led to regard the sun as a great benefactor—a great store-house of energy, supplying all our needs, clothing the world with beauty and majesty, and giving us power to respond to the influences of creation.

Coal should be regarded as energy stored up during ages. Distinguish between anthracite and bituminous coal, cannel, coke and charcoal. Formation of coal (Shaler's First Book in Geology). Relate to plants. Account for presence of carbon in sugar, paper, wool, meat, etc. Forces which produce different varieties of coal.

NOVEMBER.

PLANTS.

Select annual and biennial plants and trace life history; as—pea or morning-glory, turnip or carrot. Compare root, stem and leaves with aquatic plants. Storing of nourishment; preparation for winter.

ANIMALS.

Coverings of animals; change in coverings for different seasons. Value of skins, hair, wool, shell in commercial world.

MINERALS.

Continued study of coal. Formation of coke and charcoal; illuminating gas; other products. Relate to comfort and protection of man.

ELEMENTARY GEOGRAPHY.

Relation of barometer to change of weather. Compare fluctuations of barometer with September and October.

Relate change in animals and plants to position of sun.

NOTE.—The structure and covering of animals should be closely related to their environment and change of seasons. The economic relations of animal life should be emphasized. Call attention to man's dependence upon Nature for his necessities, comforts and luxuries.

DECEMBER.

PLANTS.

Dormant condition of plant life.

ANIMALS.

Animal movements. Compare horse, cow, dog, cat, sheep, squirrel, and man as to manner of walking. Compare hoofs, claws, paws, hands. Relate to homes, manner of getting food, intelligence.

MINERALS.

Distribution of carbon; compounds in all mineral, vegetable, and animal matter; obtained by chemical change. Relate carbon to plant life—food of animals; interchange of carbon between plants and animals.

ELEMENTARY GEOGRAPHY.

Compare variation of temperature before, during and after storm. Compare temperature, barometer, rainfall, fogs, clouds, wind with previous months. Trace snow line on signal service map.

Compare area covered by beam of light in September and December. Relate heat received in different latitudes to life.

NOTE.—Lead pupils to see stores of wealth deposited for man's convenience, comfort and progress. Civilization is man's power to overcome his environment.

JANUARY.**PLANTS.**

Effect of frost upon plant life.

ANIMALS.

Food of animals that do not migrate or hibernate.

MINERALS.

Study quartz crystals; form, size, color, hardness, texture, varieties.

ELEMENTARY GEOGRAPHY.

Compare snow line with December; when farthest north; farthest south; range of latitude covered; influence of Great Lakes.

Compare marks on shadow stick with previous months; effect upon temperature.

NOTE.—Relate effect of frost upon plants, scarcity of food of animals, the southern limit of snow line, the length of shadow to movement of sun.

Examine snow crystals. Note form, size, and law of crystallization.

Saturate solution of salt, alum, chalk, soda, blue vitriol, copperas, bichromate of potash. Note temperature of water in solution. Place solution in shallow dish or bottle with a string suspended in it. Evaporate rapidly; slowly. Relate solution to erosion of rocks; crystallization to crystalline rocks, quartz-crystals, geodes, etc.

FEBRUARY.**PLANTS.**

Any awakening in plant life. Observe trees for mosses.

ANIMALS.

Any appearance of animal life.

MINERALS.

Distinguish different species of quartz. Relate hardness of granite to quartz. Association of quartz with other minerals.

ELEMENTARY GEOGRAPHY.

Compare snow line and zero isotherm with January. Influence of wind upon course of storm.

Compare angle of sun's rays at New Orleans and Detroit. Compare relative amount of heat and light; effect upon life.

NOTE.—Relate effect of frost upon rocks to rapid disintegration. Effect of chemical and physical forces upon calcareous and silicious rock.

Read Ruskin's "Ethics of the Dust" in connection with the study of crystals.

MARCH.**PLANTS.**

Watch first awakening of the tree following outline for "Tree Study."

ANIMALS.

Note first appearance of insects. Note beauty of color, delicacy of marking. Compare fully developed insect with larva; what likenesses and differences—food, manner of feeding, locomotion.

Pond life—spawn of frogs and toads; development of tadpoles into frogs. Crayfish; turtles; snails.

MINERALS.

Water. Place a drop of salt, hydrant, lime, rain, filtered or distilled water on a clean piece of glass, and evaporate. Explain result. Relate to animal life in water, and beds of lime stone.

ELEMENTARY GEOGRAPHY.

Compare lowest and highest temperature of March with September and December. Compare most northern and southern isotherm of September and March.

Vernal Equinox. Angle of sun's rays with horizon; relate to latitude. Relation of latitude to climate.

NOTE.—Relate lime, shell life and coral in ocean to beds of limestone. Encourage pupils to make collections of land and sea shells; note beauty of texture, color, form, markings, spines, etc.

APRIL.**PLANTS.**

Continue tree study. Examine lichens, fungi, for spores. Note color, texture, form, growth of lower forms of plants.

ANIMALS.

Study dragon fly. Compare life history with that of a moth.

MINERALS.

Effect of rain upon soil. Transporting power of a stream of rapid and slow velocity. Effect of stream carrying sediment and one which does not. Relation of hardness of minerals to erosion.

ELEMENTARY GEOGRAPHY.

What isotherm passes through Detroit. Compare this with October. Compare temperature and rainfall with October.

Compare force of sunbeam in Detroit with December.

NOTE.—Pupils should observe forces acting about them, and should be led to see the great sculpturing of the face of Nature produced by same forces acting on a greater scale. Relate hardness of rock to resistance to erosion.

MAY.**PLANTS.**

Compare flowering and flowerless plants; flowers and spore cases.

ANIMALS.

Study May fly—egg deposited in water, long larval period, nymph, adult. Compare parts with other insects.

MINERALS.

Pupils should be encouraged to make field excursions, to collect and classify minerals studied during the year; to verify by observation facts learned about erosion and sedimentation.

ELEMENTARY GEOGRAPHY.

Variation of sun's rays indicated by shadow stick: changing angle of sun's rays (indicated by shadow on stick changing) to horizon; effect upon temperature and life.

NOTE.—In early spring pupils should be encouraged to go to the woods and fields and enjoy the beauty of Nature in its entirety. Discourage any careless plucking and destroying of flowers, birds, insects, or life of any kind.

JUNE.**PLANTS.**

Continue study of flowers and plants. Follow outline.

ANIMALS.

Reptiles: Compare snakes and turtles—scales, shells, manner of locomotion, kinds of food, manner of taking food, manner of laying and hatching eggs.

MINERALS.

Co-operation of mineral, plant and animal world.

ELEMENTARY GEOGRAPHY.

Compare isotherm of this month with last. The same isotherm in plains, mountains near coast lines; compare variations of isotherms in north and south. Reasons. Regions of lowest and highest temperature.

NOTE.—If the work is carefully presented in the first three grades, by the end of the fourth grade pupils should have a good, general idea of the mineral, plant and animal worlds. No attempt should be made at any scientific classifications, except that which comes from the personal experience of the pupils. Lead the pupils to see, enjoy, love and reflect upon the beauties and wonders of creation.

FIFTH GRADE.

SEPTEMBER.

PLANTS.

Make collection of fruits—fleshy, stone, dry. Compare color, texture of covering; color, texture, and marking of pit; parts of flower developed into fruit.

Fermentation: Place bottles of grape, apple, peach juice where cool, warm, light and dark. Note effect and conditions most favorable to it. During fermentation place a lighted taper in jar; effect upon flame. What might force the cork out?

ANIMALS.

Make breeding cage, collect larvae on tomato, cabbage, milkweed, caraway, maple, oak, chestnut. Supply appropriate food; watch changes.

MINERALS.

1. Pebbles. Make collections; distinguish—
 - (a) River, ocean; life history of each.
 - (b) Glacial; life history of each.
 - (c) Conglomerates; life history of each.
 - (d) Breccia; life history of each.

NOTE.—Children should now be able to do some independent work, and supplement the work of the school by making their own collections. An effort should be made to form and properly label and catalogue a collection.

A collection of leaves pressed and mounted will serve to identify related trees and plants. Seeds of different fruits may be preserved in bottles or jars and neatly labelled.

During the year they should learn the life histories of the most common insects—their form, color, marking, movements, food, habits, homes. As the eggs and skins are difficult to preserve, they can be painted or drawn and the cocoons chrysalids, and adult insects preserved. A few clear related ideas based upon individual observation are of more value than much haphazard information.

Observe formation of pebbles in a stream bed; compare with those in gravel pits; what does a gravel pit suggest? Do you find pebbles of different color, hardness, composition? Compare them with the rock in your neighborhood. What results from the formation of pebbles?

OCTOBER.

PLANTS.

Agents for distribution of seeds.

1. Wind.

- (a) Winged—pine; pappus—dandelion, thistle, milkweed.
- (b) Entire plant scattered—as Russian thistle, tumble weeds.

2. Animals.

- (a) Covering—"stick tights," sand bur, clot-bur, burdocks, pitchforks, beggar's ticks.
- (b) Feet—on hoofs of horses, cows; feet of birds.
- (c) Food—fruit eaten, digested, seeds discarded; cherries, blackberries, raspberries, strawberries, cedar by birds; oats, maize, and grasses by herbivorous animals; apples, peaches, pears, by man.

3. Water.

- (a) Streams—seeds that will float, nuts in the husk.
- (b) Ocean currents—cocoanuts.

4. Mechanical means.

- (a) Bursting pods—peas, beans, violet, bloodroot, crane's bill.
- (b) Rolling—nuts.

ANIMALS.

1. Galls.

- (a) Willow cones—at end of willow twigs along streams. Remove gray velvety scales, and find larvae in the center.
- (b) Oak galls—observe position of leaf on stem, size, structure; cut open to find larvae. Compare galls produced by a single larva with compound galls containing many cells.
- (c) Mossy rose galls. Compare structure with oak gall.
- (d) Conical galls on witch hazel. Find opening.
- (e) Poplar galls. Compare those at base of leaf and those on end of a twig.
- (f) Golden rod galls. Compare with oak galls as to location on plant.

What causes local enlargement of plant?

MINERALS.

Observe mineral deposit in your neighborhood. Is it limestone, sandstone, granite, marble? What are the physical characteristics? From your study of pebbles, can you give a reason for the structure of

any of the rock? Do you find any layers in the rock—are they horizontal, vertical, or tilted? Have the rocks changed any during the last six months? If they are wearing away, what agents are active?

NOTE.—In studying distribution of seeds the results of observation should be tabulated. Count number of seeds in each pod or husk and number produced by each plant.

Plant.	Number of Seeds.	Means of Distribution.
Annuals: Corn Beans.	200 on cob, 2 cobs, 400. 10 in pod, 20 pods, 200.	Animals. Bursting pods.
Biennials: Carrot. Turnip.		
Perennials: Apple. Grape.		

Relate cultivation to production of seed. Children should very early get the idea of the great interdependencies of the animal, vegetable, and mineral worlds; the great amount of plant food which is locked up in the rocks, the agents which are at work unlocking this plant food and making it available. They should see in the rocks great store houses of energy which must be liberated, and become familiar with the organic and inorganic agents at work.

NOVEMBER.

PLANTS.

Life histories of plants.

Work of a plant—taking food and reproducing its kind.

Vegetative parts of plant—root, stem, leaves; reproductive parts—flower and fruit.

1. Annuals.

Those which usually mature seed during a year, as corn, beans, peas, phlox, morning-glories, etc.

2. Biennials.

Those that store nourishment in some part of plant first year to be utilized in developing seed second year.

Nourishment in root—turnip, parsnip, beet, radish; stem—potato, cabbage, celery; leaves—cabbage, cauliflower, century-plant.

3. Perennials.

Those that bear fruit year after year.

ANIMALS.

Collect and compare cocoons, chrysalids, and nests of insects, noting form, size, texture, material.

Pupa stages of *Cecropia*, *Polyphemus*, *Promethra*, *Sphinx* moth, *Luna* moth, bag-worms, leaf rollers, various wasps nests.

Compare cocoons in breeding cages with those found in the woods and fields.

MINERALS.**1. Soils.**

- (a) Examine sands, gravel, loam, clay.
- (b) Power of each to absorb and retain moisture.
- (c) Power of each to absorb and retain heat.
- (d) Relation of soil to plant and animal life.
- (e) Relation of physical properties to fertile and desert regions.

NOTE.—Tabulate number of seeds produced by annuals, biennials, and perennials. Relate number of seeds to effort of plant to perpetuate its kind. Compare seeds of annuals with those of perennials as to color, form, texture, abundance and means for distribution. Compare food values of annuals, biennials, and perennials, and the part of the plant utilized.

To gain some idea of the various constituents of plants, weigh a turnip, potato, some seeds, or fruit; dry thoroughly and weigh again; burn the dried vegetable matter and weigh the ash, and tabulate results.

	Weight.	Water Evaporated.	Carbon Consumed.	Ash or Mineral.
	oz.	oz.	oz.	oz.
Turnip. Potato. Apple.				

The life in an aquarium or breeding cage is abnormal and the main object of having them in the school room is to interest the children and stimulate observation and investigation. The specimens secured by the effort of the individual child are of the greatest value to him. The teacher should suggest and direct.

Make collections of different soils, as sand, gravel, loam, and clay, and intermediate stages as sandy loam, sandy clay, etc. Distinguish physical characteristics—color, texture, composition, weight, etc.

Test temperature under ordinary conditions; subject all to the same degree of heat; test again, does the mercury indicate an equal increase in temperature? Subject all to the same degree of cold; test again. Have all given up an equal degree of heat?

Power of each to absorb and retain moisture. Tie a circular piece of cheese cloth over the top of a tumbler in such a way as to form a

bag in the tumbler. Arrange four in the same way. Put a gill of sand, gravel, loam and clay respectively in each of the bags. Pour a gill of water through the soil in each glass, being careful to have all pass through the soil and not the cloth. After six hours compare the amount of water in the glasses. Which soil retained the most water?

Soil.	Water in Soil.	Soil in Water.	Temperature.
No. 1. Sand. No. 2. Gravel. No. 3. Loam. No. 4. Clay.			

Effect of freezing upon soil; upon water in a bottle. Frozen water pipes.

Relate experiments to rainfall and its effect upon soil; to formation of flood plains; to material carried in suspension by streams; formation of springs; effect of heat and moisture of soils to plants and animals.

Remove bags containing soils and expose them to different conditions of air—a dark, cool place, sun light and wind. Which soil yields its moisture most readily, and under what conditions. Relate this to exposure of fields to atmospheric conditions.

Germinate seeds under different conditions of soil, moisture and atmospheric conditions.

DECEMBER.

PLANTS.

Dormant condition of plant life. Compare the buds on different trees; can you distinguish the leaf and flower buds; the live and frozen buds? Which buds have the most effective covering? Open a few to note internal conditions. Which is most destructive to twigs and buds, continued cold or a variable temperature, very dry or very wet soil? What effect has the heaving of the soil on the roots of plants?

ANIMALS.

Compare life conditions in an aquarium with condition in cocoons and nests collected. What changes, if any, are taking place in each? What insects have you observed that develop without metamorphosis; incomplete metamorphosis; complete metamorphosis.

MINERALS.**1. Origin of soils.**

- (a) **Materials**—disintegrated rock and decayed organic matter.
- (b) **Agencies at work**—water, air, frosts and glaciers, low orders of plants, earth worms, high orders of plants, chemical action.

What agents have you observed that are active during the winter?

NOTE.—The too common opinion is that plants should be studied only in spring, summer, and autumn. The winter condition is the most trying, and should have its attention. The individuality of the trees and shrubs is more apparent, the characteristic branching, color and texture of bark, arrangement and protection of buds. Observe the "winter rosettes" in the grass.

There is such a ruthless destruction of the young evergreen forests for Christmas that an effort should be made to have trees planted in their places.

In no place in the realm of nature is the using over and over again of the same material more apparent than in the relation of plant life to soil. The plants absorb the mineral matter through the roots and the carbon dioxide through the leaves. When the different parts of the plants have performed their functions they fall to decay—the carbon uniting with the oxygen of the air and passing into the atmosphere as a gas and the mineral matter reverting to the soil; the plants form a connecting link between the mineral and animal worlds and both finally return to the mineral world.

To show that plants act chemically upon rocks, germinate a few seeds in a clam shell or on a piece of marble; remove the soil and observe tracing on shell or marble. Fold a piece of blue litmus paper around the roots of beans and corn germinated between blotting paper. The color will turn to pink showing the acid reaction, proving that the roots are giving out an acid. Dissolve a piece of egg shell, coral, clam shell, marble and limestone in strong vinegar or hydrochloric acid. Try clay sandstone and granite; which yields to the acid? What kind of rock would plants affect most? Have you observed any instances when the growth of roots has split the rocks? The roots of plants make the soil more porous and allow water containing acids in solution to have access to underlying rocks, causing them to disintegrate. Note the variety of mosses and lichens on granite boulders and exposed surfaces of rock. What is their effect? What relation do you see between the water, air and frost and disintegration of rock?

JANUARY.

PLANTS.

Effect of frost upon plants. Select a number of twigs from fruit and forest trees and count number of buds formed, dormant, frozen.

What proportion are in good condition? Which trees suffer most, those on north or south side of a house; of a street; northern slope of a hill or southern slope? Would you plant fruit trees on a hillside, facing a lake, near the base, top, or on the slope? Why? Distinguish between air, drainage and water drainage in their relation to plants.

ANIMALS.

Economic relation of insects. Make a study of the silk industry. Compare food, habits, cocoons with the silk spinners of your own neighborhood.

MINERALS.

Agents at work on surface.

1. Air. Destructive action of moist air; of changes of temperature; of wind. Constructive action.

2. Water.

(a) Rain.

Its chemical action, producing weathering. Soil.

Its mechanical action, removing and renewing soil.

(b) Rivers and streams.

History of river from source to mouth. Its destructive and constructive effect. Bars.

(c) Ice.

Destructive effects of frost, frozen rivers and lakes.

3. Life.

Plants and animals are destructive and constructive agents. Soil, peat, mosses, coral reefs and limestone.

NOTE.—A few fundamental ideas about absorption and radiation of heat and its relation to currents of air will give children a knowledge of the best life conditions of plants.

Material for the study of the silk worm can be secured from silk manufacturers, and sometimes from the Smithsonian Institute, at Washington.

The study of the soil producers might be classed as geographical nature study. Geography is no longer the study of flat, brightly colored maps with a few black lines for rivers and various sized dots for cities and towns. The universe is a wonderful laboratory in which great physical and chemical and biological forces are at work. Children should be led to realize and appreciate the constantly changing relationship between earth, air, water and life.

FEBRUARY.

PLANTS.

Effect of warm days upon plants. Which trees expand most quickly? Which buds swell first? Watch for dandelion blossoms.

ANIMALS.

Winter condition of insects. Examine trees for egg masses of tent caterpillar and forest tentless caterpillar, bark of trees for cocoons of codling moth. What birds are seen feeding on eggs and larvae in the trees? Imagine the hiding places of insects, and life conditions.

MINERALS.

Kinds of rock.

Examine different kinds of rock in your neighborhood. Is it sandstone, limestone, marble, slate, shale, or granite? Compare texture, hardness, cleavage. Which yields to erosive agents most rapidly? What is the nature of the soil derived from the different kinds of rock? Do you find evidences of life in any of the rocks?

NOTE.—A few warm days may be sufficient to arouse activity in plants, and children should be on the alert for first evidences. A *Venessa* butterfly which has been hibernating in the bark of a tree may be lured from its hiding place. When we think of the myriads of insects that swarm during the summer, it is interesting to contemplate their abiding places during the winter. After vegetation has been killed is a good time to study the rock structure; long fringes of icicles on the breast of a ledge of rock speak plainly of the frost giants at work there; masses of rocks dislodged will disclose a tracery of rootlets; the talus formation at the base of the cliffs show the wreckage, much of which will be carried away by the spring freshets.

MARCH.

PLANTS.

Cut twigs from different trees and bring into the school room for daily observation. Compare color and texture of bark; length of a year's growth; position and size of buds; leaf and flower buds. In fruit twigs can you detect fruit spurs? Relation of fruit spurs to growth of twigs. Compare covering and protection of buds. Observe the way leaves and blossoms are folded in buds.

ANIMALS.

First appearance of insects; have they hibernated or emerged from cocoons or nests?

Make an insect calendar for school, or encourage each child to keep his own calendar.

Common Name.	Scientific Name.	Date of Appearance.	Laying Eggs	Deposition of Eggs.

Hatching of Eggs.	Larval Period.	Pupa Stage.	Adult.	Stage of Winter Condition.	Remarks.

MINERALS.

Erosive work of rivers.

1. Rain.

- (a) Supplies water to surface and underground streams.
- (b) Carries acids in solution.
- (c) Carves soft rock.
- (d) Wears harder rock.
- (e) Carries sediment to streams.

2. Underground Streams.

- (a) Dissolve mineral matter.
- (b) Form caves in calcareous rock.
- (c) Furnish river with mineral matter in solution.

3. Rivers.

- (a) Slowly dissolve rock in stream bed.
- (b) Wears stream bed.
- (c) Meanders and broadens its valley.
- (d) Carries and wears detritus supplied to it.
- (e) Assorts and deposits material in bed.
- (f) Forms waterfalls, gorges, canons and broad valleys.

NOTE.—It is important that the buds should open in the house, because later in the spring so many things claim attention that they are apt to be neglected. It is not so important that children should gain a great many facts as that they should have the right attitude toward nature. It is not best for them to be told a great many things; they should see a great many things for themselves.

The life histories of insects, appearance and disappearance, is of the greatest importance to persons who are to live on the farm. Their habits are exceedingly interesting in themselves and a knowledge of their habits is of great value in combatting them. Children should be encouraged to keep the calendar year after year. They easily acquire scientific names, and it is well for them to begin the work correctly, although not necessary for an appreciation of insects.

There are very few schools that have not access to a stream. Pennsylvania has such noble rivers, children should be encouraged to read the chapter in the history of the State that these streams are writing.

APRIL.

PLANTS.

Germination of seeds.

I. Seedage.

1. Requisites for germination.

- (a) Moisture.
- (b) Free oxygen.
- (c) Definite temperature.
- (d) Influence of light.

2. Experiments.

(a) Moisture most important factor.

- (1) Place a gill of each of several kinds of seeds, as corn, beans, peas, wheat, in a glass. Pour over each a gill of water. Observe absorption of water at end of twenty-four hours.
- (2) Plant some of each kind of seeds in dry, moist and wet soils. Observe germination according to amount of moisture.

(b) Free oxygen.

- (1) Plant seeds under favorable conditions as regards moisture, in jars. Cover one with glass to exclude air, and leave the others exposed to atmosphere. Note effect.

(c) Definite temperature.

- (1) Expose germinating seeds to cold, cool, warm, and hot temperatures. Observe most congenial conditions.

(d) Influence of light.

- (1) Submit germinating seed to light, shade, and darkness. Observe best conditions for germinating.

II. Testing Seeds.

Soak a given number of seeds, as 100, or if preferred, all that one plant produced, as a pea vine, morning-glory vine. Note successful and unsuccessful efforts at perpetuation of species.

III. Sowing of seed.

Teach children to apply the principles gained from the above in practical experience. Encourage formation of gardens.

IV. Uses of Plants.

- (a) Which are used for food of man? Of horse? Of cow? Of sheep? Of swine? Of fowls?
- (b) Which are valued for their seeds? Their fruits? Their leaves? Their stalks? Their roots?
- (c) Which are planted in hills or drills and tilled? Which sown broadcast or in close drills and not tilled?

- (d) Study effect of shallow and deep planting on different seeds.
- (e) Observe the usual time of planting and of harvesting different crops.

ANIMALS.

Study moths and butterflies. If cocoons are kept in a warm place the moths and butterflies usually come out some time in April. Keep in a conspicuous place. Note the opening, size and shape. Note condition of wings and body at time of egress. Note time from first appearance until wings are entirely expanded. Note number, color and form of eggs. Learn different parts of body. Compare with larva.

MINERALS.

Study capillarity of soils in relation to germination of seeds and gardening. Preparation—blotting paper in a drop of ink; lump of sugar in tea; piece of crayon in ink; wicks in candles; lamp wicks; explain. Put glass tubing of large and small bore in colored water. Note difference in height of water in tubes. Fill a pan with sand. Fill four argand lamp chimneys respectively with sand, gravel, loam, and clay. Stand them in the pan of sand with large end down. Pour water over the sand in the pan. In which chimney does water rise most rapidly? What becomes of it? Compare this experiment with experiments with soils for November. Fill a chimney with compact soil nearly to the top. Add some dry loose sand. Do you notice any difference in the action of the water? Relate these experiments to tillage of the soil.

When soil moisture, or the water table is too low to be useful to plants, capillarity may be established by rolling loose soil and making it more compact, thus bringing the water to a place where it is available. To prevent its evaporation, the soil should be ploughed or harrowed, forming an earth mulch, thus destroying capillarity.

Why should we try to conserve the winter rains and snows? What effect would rolling have upon soil? How could you prevent the moisture from being lost by evaporation? Walk over finely ploughed ground. What makes the foot print so apparent in a short time? What is meant by earth mulch and what is its value?

NOTE.—There is such a difference in the vitality of seed and so much poor material put in the market it is well to know how to test seed, to determine the per cent. that will grow; before planting, seed must have proper life conditions in order to develop in the most vigorous manner.

MAY.**PLANTS.****I. Leaves.****1. Form.**

- (a) Simple—parallel and netted veined; lily, geranium.
- (b) Compound—palmately and pinnately; horse-chestnut and walnut.

2. Arrangement—opposite and alternate.**3. Adaptation.**

- (a) Light—turning edges or upper surface to sun.
- (b) Heat—folding to prevent radiation; development of hairs.
- (c) Moisture—surface for absorbing, as thistle; shedding, as mullein.
- (d) Rain—shedding from plant axis, as horse-chestnut, to be absorbed by tips of roots; shedding toward plant axis—violet, mullein, burdock, plantain, turnip. Upper surface of leaves channelled, leaves folded in cups, petiole grooved, leading to tap root.

4. Modification.

- (a) Support, tendrils, entire leaf, as grape; part of leaf as sweet pea; petioles of leaves as clematis.
- (b) Food—pitchers of pitcher plants; viscous tentacles of *drosera* or sundew; trap of Venus-fly.
- (c) Reproduction.
 - (1) Evergreens—scales of cones and catkins.
 - (2) Flowers—calyx, corolla, stamens and pistils.
- (d) Storehouse for food—cabbage, house leek, century-plant.

ANIMALS.**Social Communities of Ants.**

- (a) Colony—males, females, or queens and workers. Males and females winged and workers wingless.
- (b) Eggs very small, not easily seen.
- (c) Larvae white and legless.
- (d) Pupae—some enclosed in oblong, egg-shaped cocoons; others naked. Look out for nests; in decayed stumps covered with moss, under stones, in sand, and in the woods. Contrast life conditions. Observe black ants on trees and shrubs. What is their association with aphids or plant lice.

Construct an ant nest for observation.

MINERALS.

Of what value are ants to soil? In what kind of soil do they work most?

Make careful observation of the work of earth worms. On what kind of soil do you find castings most abundant; relation to porosity and capillarity of soil; to rainfall and evaporation. Estimate the number of earthworms in an acre of good soil.

NOTE.—Mark off a square yard in sandy soil, on a grassy plot, and under trees. Remove all the earth worm castings. Collect castings every twenty-four hours.

	A.M.	Clear or Cloudy.	Temperature.	Bar.	Sand.	Grass.	Trees.	Single Casting.
			Degrees.		Gr.	Gr.	Gr.	Gr.
May...	8.00	Cloudy.	50	29.7	7.15	42.5	43.75	4
May...	8.00	Clear.	70	29.7	4.7	21.7	107.2	3

By computing the amount of soil brought to surface in twenty-four hours and comparing the area of a square yard with an acre, some idea can be gained of the amount of work being done by these humble but effective agents. Read Charles Darwin's work on earth worms.

JUNE.**PLANTS.****1. Flowers.**

(a) Form—regular and irregular; texture; color; markings of flower in relation to insects. Maturing of pistils and stamens.

(b) Pollen.

(1) Distribution—by wind and insects.

(2) Protection.

Against rain; nodding—fuschia, columbine; method of closing during rain or cloudy weather—poppy; irregularity of flowers—iris, sweet pea.

Against animals; hairs on leaves, flowers on throat of flower—mullein, thistle, violet; latex—milk in stem and leaves, hardens in air, stalk smooth, epidermis delicate, feet of insects puncture epidermis, are caught and stick—milkweed; isolation—teasel, pond of water in cup formed by leaf; shape of flower—sunflower, sweet peas, snap-dragon, milkweed, orchids, yucca, salvia, catnip.

ANIMALS.

Study bees, wasps, butterflies and moths in connection with fertilization of flowers.

- (a) Bees—honey bee, leaf cutter bee, solitary bee, bumble-bee.
Community—males or drones, females or queens and workers.
- (b) Wasps—solitary wasps, social wasps, and digger wasps.

MINERALS.

"Fill a flower pot with soft, dark earth and mold from the border of the wood and carry it to the student of entomology, and see if he can name one half of the living forms of this little kingdom of life; or hand it to the botanist, well trained in the lower orders of plants, and see how many of the living forms which these few handfuls of dirt contain he can classify. Present this miniature farm to the chemist and the physicist and let him puzzle over it. Call in the farmer, and ask him what plants will thrive best in it; or keep the soil warm and moist for a time and have the gardener say of the tiny plants that open as if by magic, which are good and which are bad. Mark well what all these experts have said and call in an orchidist to tell you how to change dead, lifeless, despised earth into fruit; ask the physiologist to explain how sodden earth is transformed into nerve and brain."—(Taken from "The Fertility of the Land," by Prof. I. P. Roberts, Cornell University.)

NOTE.—The perpetuation of the species depends upon the vitality of the seed. Continued self-fertilization produces weak seed; cross fertilization is a toning up process and is effected by the structure of flowers and aid of insects. Close study will reveal the secrets.

If possible have a bee hive in the school room for observation. It can be arranged with glass sides, so that the bees will not have access to the room. Nests of bumble-bees will be found in deserted nests of field mice. Observe rose leaves for work of leaf cutter bee. Can you find the nests? Collect nests of solitary and social wasps. Inspect dead branches of sumach and other pithy plants for nests of bees, wasps, and digger wasps.

Read "Bees, Ants, and Wasps," by Sir John Lubbock.

INSECTS.

There is no problem so difficult for the farmer to solve as the economic relation of insects. It is well, therefore, for the children to become acquainted with the life histories of insects that they may have an intelligent interest in and a keen appreciation of those which are injurious and those which are beneficial. There is much valuable literature on the subject. The best results are secured by studying the creatures themselves in their native haunts, and live speci-

mens in the school room. An equipment for collecting is simple and can be made by an ingenious teacher or pupil.

Collecting Net:

The ring should be of iron or brass wire, ten to twelve inches in diameter, fastened to a wooden handle about three feet long. The bag can be made of cheese cloth or unbleached muslin.

The Killing Bottle:

Take a wide-mouthed bottle holding four or six ounces, or for large moths, a Mason self sealing fruit jar. Put into the bottle a cubic inch of cyanide of potassium and cover with water. Add enough plaster of Paris to entirely soak up the water. Keep the bottle open until entirely dry, and then keep securely corked.

Directions for mounting and preserving insects can be found in "Insect Life," by John Henry Comstock, a book which is full of suggestion for the work.

The most valuable study can be made by keeping insects in breeding cages. These can be simply made by tying mosquito netting or Swiss muslin over the top of a box, or by putting a lamp chimney or broken fruit jar on the top of a flower pot filled with soil. The soil should be moist and the food material of the larvae renewed every day. Larvae in different stages of development should be secured to compare markings of different moults.

The movements, manner of eating, amount of food consumed, moulting, varied markings of different stages, protective and attractive coloration, means of defense—as spines, bristles, secreted liquid—the sluggish condition before transformation, will be of continued interest day by day.

Larvae of different insects should be collected and carefully observed. A record should be kept of the different species, as to time of collecting, of going into pupa stage, and of changing into the adult. The larvae on the tomato plant, cabbage, milkweed, wild carrot, horse-chestnut, maple, oak, will supply valuable material. The larval, pupa and adult stages should be associated so that one would recall the others. It is well, but not necessary, for the children to be familiar with the scientific names; they should know the scientific facts and their interest will lead to deeper study.

There is so much that is interesting in pond life that an aquarium is a valuable addition to the school room. Suitable jars or fish globes or battery jars can be secured at moderate prices, but a fruit jar can be used. The plant and animal life in the water will demonstrate the interdependence of one upon the other. If the aquarium is properly stocked the equilibrium will be preserved; the plants will keep the water pure.

The Aquarium:

PLANTS.

Water cress, duck weed, frog spittle, slime wort, bladder wort, water weed.

ANIMALS.

Water scavenger beetle, back swimmer, water scorpions, water bugs, mosquito larvae, water boatmen, nymphs of dragon and damselflies, nymph of May flies, caddice larvae.

ANTS.

An ant's nest in a school room is a source of much interest and delight. An artificial nest can be cheaply and easily constructed. Partially fill a tin or galvanized iron pan 12x15x2½ inches with water. Above the water, support a pane of glass 10x10 inches on small blocks of wood. Remove an ant's nest from the ground or a decayed stump and put it on the glass, spreading it so that when a second pane is placed on top the space between the panes will be one-quarter of an inch. Cover the glass with a piece of cardboard to exclude the light, removing only during observation. Keep the soil moist, and supply food—crumbs or sugar. In addition to the nest, a park can be made in a dish containing moss, decayed earth, and material the ants have been accustomed to in the woods. Connect the park and nest. The community life seen through glass is of great interest.

PLACE OF INSECTS IN ANIMAL KINGDOM.

INVERTEBRATES.

1. Branch.

(a) Arthropoda.

2. Class.

(a) Crustaceans—crayfish, sow bugs.

(b) Arachnida—spiders, scorpions, grand-daddy-long-legs, mites, and ticks.

(c) Myriopoda—centipeds, millipeds.

(d) Hexapoda—insects.

PARTS OF AN INSECT.

1. Head.

(a) Antennae—"feelers."

(b) Compound eyes.

(c) Simple eyes or ocelli.

(d) Mouth parts.

- (1) Labrum—upper lip.
 - (2) Mandibles—jaws.
 - (3) Maxillae, and maxillary palpi.
 - (4) Labium and labial palpi.
2. Thorax.
 - (a) Prothorax.
 - (1) First pair of legs.
 - (b) Mesothorax.
 - (1) Second pair of legs.
 - (1) First pair of wings.
 - (c) Metathorax.
 - (1) Third pair of legs.
 - (2) Second pair of wings.

Wing—veins and cells.

Legs—coxa, trochanter, femur, tibia, tarsus, and claws.
3. Abdomen.
 - (a) Ears (in locust).
 - (b) Spiracles—breathing holes.
 - (c) Ovipositors—for depositing eggs.

METAMORPHOSIS OF INSECTS.

1. Developtment with Metamorphosis.
 - (a) Stages—egg, immature insect, adult.
 - (b) Examples—Thysanura.
2. Incomplete Metamorphosis.
 - (a) Stages—egg, nymph (several stages), adult and imago.
 - (b) Examples—locust, cricket, dragon fly, damsel fly, May fly.
3. Complete Metamorphosis.
 - (a) Stages—egg, larva, pupa, imago.
 - (b) Examples—moths, butterflies, bees, ants, beetles, flies.

ECONOMIC RELATIONS OF INSECTS.

1. Effects.

\$400,000,000.00 of the agricultural products of the United States are annually destroyed by insects. The Codling-moth exacts a yearly tax of \$3,000,000.00 in one State.

Many insects are injurious and many are very beneficial.

2. Warfare against Insects.

- (a) Is the insect injurious?
- (b) How does the insect feed?
 - (1) Mouth parts formed for sucking.
 - (2) Mouth parts formed for biting.
- (c) How can it best be attacked and when?
- (d) Are mechanical or chemical means most effective?

3. Some Mechanical Methods.

- (a) Hand-picking—tomato worm, pear tree borer.
- (b) Collecting and destroying eggs—tent caterpillar and forest tentless caterpillar.

4. Insecticides.

- (a) Biting insects—Paris green or Bordeaux mixture for potato beetle and codling moth.
- (b) Sucking insects—kerosene emulsion.

5. Spraying.

- (a) Apparatus for spraying.
- (b) How to spray.
- (c) When to spray.

The time will depend upon the vulnerable stage or period of the pest.

Children should learn the principle and working of the lifting and force pump.

INJURIOUS INSECTS.**1. Apple Pests—nearly 400 insect pests.**

- (a) Roots—wooly aphis.
- (b) Trunk—round-headed and flat-headed borer.
- (c) Leaves.
 - (1) Spring and Fall canker worm. Observe trunk at night.
 - (2) Apple tent caterpillar. Collect eggs and destroy.
 - (3) Forest tentless caterpillar. Jar off and kill.
 - (4) White-marked tassock moth.
 - (5) Red-humped apple worm.

(d) Fruit.

- (1) Codling moth.

Eggs laid on surface of apple or adjacent leaves. Caterpillars emerge in about a week, enter fruit and calyx.

Larval stage inside apple; emerge through a hole in the side of the apple; crawl into crevice of bark or elsewhere.

Pupa stage, a week or two. Moths emerge for a second brood. Change to pupa may not take place until spring.

Spray with Bordeaux mixture.

- (a) Before the blossom opens.
- (b) After the blossoms fall.
- (c) A week later.

2. Plum Pests.

- (a) Fruit.

Plum curculio. Observe the insect lay the egg in fruit. Jar tree and destroy affected fruit.

3. Peach Pests.**(a) Trunk and roots.**

Peach tree borer. Dig out borers before July 15, and destroy.

4. Cherry Pests.**(a) Fruit.**

Cherry fruit fly. Lays eggs through skin of reddening cherry; maggot feeds on pulp near it. Maggot leaves fruit; goes to ground, transforms to parent fly in spring.

5. Grape Pests.**(a) Leaves and buds.**

Grape vine flea beetle. Small blue beetle attacking swelling buds. Destroys crop.

6. Currant Pests.**(a) Stems.**

Two borers, adult of one a beetle, of the other a moth. Cut out and destroy infested stalk.

(b) Leaves.

Imported currant worm. Green worm, larva of saw-fly. Eggs layed along veins in under side of leaves.

7. Raspberry and Blackberry Pests.**(a) Canes.**

Raspberry cane borer. Cut and burn wilted tip of cane.

(b) Leaves.

Raspberry saw-fly. Eggs on leaves in spring; larva—thickly spined green worm. Pupa stage in ground.

8. Potato Pests.**(a) Leaves.**

Colorado potato beetle. Hibernates in ground. Five hundred to 1,000 eggs. Grows full grown in two or three weeks. Pupate in ground. Grubs and beetles feed upon leaves.

9. Totmato Pests.**(a) Leaves.**

Tomato larva. Larva green or brown in color. Pupa stage in ground. The adult, the Sphinx moth.

Often attacked by Ichneumon fly, which deposits eggs under skin. Larvae feed upon caterpillar. On emerging they spin white cocoons.

10. Cabbage and Cauliflower Pests.**(a) Leaves.**

Eggs on leaves. Caterpillar full grown in two weeks. Butterflies emerge from chrysalis in ten days. One of the best species to observe the life history, it is completed in so short a time.

SOME OF NATURE'S INSECTICIDES.

1. Wind.—Removes from trees.
2. Temperature.—Insects can endure extremes but not variation.
3. Rain.—Destroys plant lice.
4. Fires.—Destroy insects in all stages, especially those infesting decayed wood.
5. Birds.—Prey on the egg, larval, pupa, and adult stages of insects.
6. Predaceous Insects.—Prey on other species, in air, as dragon-fly; in water as scavenger beetle.
7. Ichneumon Flies.—Deposit eggs in larva of insects; in mines of the engraver beetle. Remove bark and compare engravings of different species.
8. Mantis.—Habits of mantis or praying insect.
9. Spiders.—Traps for catching insects—funnel web, orb web.
10. Frogs and Toads.—Structure of mouth for catching insects.
11. Lady-bug.—Destroys San Jose Scale and aphids, very beneficial and should be protected.

OUTLINE FOR TREE STUDY.

ALL GRADES.

Cause each pupil or class to select an individual tree for systematic and consecutive study throughout the year. If a maple is chosen, careful observations should be made and recorded in writing, painting, and drawing; different species as to shape, symmetrical development, bark, wood, leaves, flowers, fruit, etc. Skillful effort on part of teacher may foster love for trees that shall be life-long.

I. Environment.

- (a) Open fields—symmetrical development.
- (b) In a forest—tall, slender, etc.
- (c) Near another tree or house—development irregular.

II. Shape.

- (a) Excurrent—development of terminal buds.
- (b) Deliquescent—development of lateral buds.

III. Symmetry.

IV. Parts of Tree.

(a) Roots.

- (1) Tap-root—long root deep in ground, as nut trees, hickories.
- (2) Multiple roots—many large roots extending outward from trunk, as in maple, elm, horse-chestnut, poplar.
- (3) Primary roots—growing from root-end of embryo, as in apple, peach, cherry.
- (4) Secondary roots—growing from slips or stems, as in willow.

(b) Stems and Branches.

- (1) Tree—plant of woody structure branching some distance above ground.
- (2) Shrub—plant of woody structure branching directly above ground.
- (3) Exogenous stems—separable bark, wood in annual layers, as maple, oak, etc.
- (4) Endogenous stems—no separable bark. Woody substance in threads within pithy material; as palmetto, cornstalk, etc.

(c) Bark.

- (1) Birch—bark peels in thin horizontal layers.
- (2) Ash—bark opens in many irregular netted cracks near each other.
- (3) Chestnut—bark opens in longitudinal cracks quite distant from each other.

(d) Wood.

- (1) Heart-wood—dead, dark, central wood.
- (2) Sap-wood—carries sap in growing season.
- (3) Medullary rays—silver grain.
- (4) Annual layers—minute tubes or cells. Large in early growing season; small in late growing season.
- (5) Age of tree generally told by annual layers.

(e) Branches.

- (1) Opposite leaves, generally opposite branches.
- (2) Alternate leaves, always alternate branches.
- (3) Erect, horizontal and drooping Lombardy poplar, pine and weeping willow.

(f) Buds.

I. As to Position.

- (1) Terminal—at end of twig.
- (2) Lateral—along sides of twig.
 - (a) Axillary, in the leaf axil.
 - (b) Accessory, buds clustered around axillary buds.
 - (c) Adventitious, buds produced irregularly.

Nodes—points on stem at which buds are produced.

Internodes—spaces between nodes.

II. As to Activity.

- (1) **Active**—those that develop.
- (2) **Dormant**—those that form but do not develop.

III. As to Covering.

- (1) **Scaly**—covered with dry, tough, bark-like layers.
- (2) **Naked**—without scaly covering.
- (3) **Hidden**—those buried under or in bark.

IV. As to Arrangement.

- (1) **Opposite**—two at same node and opposite.
 - (2) **Whorled**—three or more arranged around the same node.
 - (3) **Alternate**—in ranks around stem not being opposite or whorled.
- (g) **Leaves**—lungs of plants.
- (1) **Arrangement**—alternate — poplar; opposite—maple; clustered—pines; scattered—spruce.
 - (2) **Parts**—blade—thin expanded portion; petiole—leaf stalk; stipules—pair of small blades at base of petiole.
 - (3) **Veining**—parallel, netted; midrib—central line; ribs—second in size; veins—third in size; veinlets—minute lines.
 - (4) **Kinds of leaves**—simple—one blade, compound—more than one blade, palmately compound—blades from one point, pinnately compound—blades arranged alongside.

V. Forms of leaves—broadcast in the middle—orbicular, oval, elliptical, oblong, linear, needle-shaped; broadest near base—deltoid, ovate, cordate or heart-shaped, lanceolate, awl-shaped, scale-shaped; broadest near apex—obovate, obcordate, oblanceolate, cuneate or wedge-shaped.

- (1) **Bases of leaves**—cordate or heart-shaped, auriculate. Abrupt, tapering, peltate or shield-shaped, reniform or kidney-shaped, halberd-shaped, oblique.
- (2) **Apexes of leaves**—truncate, retuse, emarginate, obcordate, obtuse, acute, acuminate, bristle-pointed, spiny-pointed, mucronate.
- (3) **Margins**—entire, repand, sinuate, dentate, serrate, crenate, lobed, notched, cleft, parted, divided, pin-natifid.

VI. Nature of Leaves.

- (1) Surface—pubescent, glabrous, canescent, scabrous.
- (2) Texture—succulent, punctate, membranous, thick, thin.

OUTLINE FOR TREE DESCRIPTION.

Tree as a whole: size, general form, trunk, branching, twigs, character of bark, color of bark on trunk, branches, and fine spray.

Leaves: parts, arrangement, kinds, size, thickness, form, edges, veining, color, surface, duration.

Buds: position, size, form, covering, number, color.

Sap and juice.

Flowers: size, shape, color, parts, odor, position, time of blooming, duration.

Fruit: size, kind, form, color when young and when ripe, time of ripening, substance, seeds, duration, usefulness.

Wood (often necessarily omitted): hardness, weight, color, grain, markings, durability.

Remarks: the peculiarities not brought out by the above outline.

FOUR FORMS OF TREE DESCRIPTION.

- I. A bare skeleton written by aid of topical outline from observation of single tree and its parts.
- II. A connected description conveying as many facts given in outline as can well be brought into good English sentences. This a description of a single tree.
- III. A connected readable description of a certain kind of tree, made up from observation of many trees of same species to be found in neighborhood.
- IV. Fourth description, including information to be obtained from outside sources in regard to origin, geographical distribution, hardness, character of wood, habits, durability, etc.

NOTE.—The outline for study of a tree is for entire year. Tree should be selected at opening of school year. Monthly drawings and written descriptions by each child regarding its condition at that time. Papers should be of uniform size, properly dated, so that by June the record for a year will be complete. Specimens of autumn leaves, showing depredations of insects, pressed and mounted. Collection of seed made. Specimens of twigs from north, east, south and west sides mounted and compared. Carefully prepared transverse and longitudinal sections of wood. Specimens of newly developed leaves pressed and mounted, showing exposition of leaf area to sun. Specimens of flowers mounted and preserved. Written description should relate growth of tree to atmospheric conditions, soil, etc., and should contain everything that influences its growth.

DRAWINGS.

September—Leaves showing depredation of insects, insects' nests, cocoons, birds' nests and birds found in tree.

October—Groups of fruit—transverse and longitudinal sections, seed.

November—Twig showing buds and scars.

December—Tree as a whole showing shape of top, cone, sphere, hemisphere, oval, ellipse.

January—Transverse section of wood.

February—Longitudinal section of wood.

March—Drawing of twig.

April—Transverse and longitudinal section of bud.

May and June—Weekly drawings showing development, enlarged bud, arrangement of scales, opening buds, flower and parts of flower.

TREES FOR DIFFERENT GRADES.

First. Horst-chestnut, maple and spruce.

Second. Oak, hickory and pine.

Third. Fruit trees—apple, cherry, plum; fir.

Fourth. Willow, sycamore, poplar, hemlock.

Fifth. Comparison of trees commercially: as to food, building material, fuel, machinery, railroads, ships, telegraph and telephone poles, arts and sciences.

Sixth. Distribution of trees as to latitude and altitude. Comparison of foreign and domestic woods.

Seventh. Effect of ruthless destruction of trees. Famous trees in history.

Eighth. Literature of trees.

The horse-chestnut is chosen for the First grade because the parts are large and conspicuous, and can be easily discovered by the unskilled hand and untrained eyes of little children; the maple for its beauty, abundance, graceful form of fruit, and brilliant coloring of its leaves in the fall; the spruce, that comparisons may be made between evergreen and deciduous trees, and because of its relation to Christmas.

The oak, hickory and pine may be studied as supplying food for the squirrel. The leaves and acorns of as many different oaks, as possible, should be collected and form, size, color, texture of leaves, cups and acorns compared. One class found thirteen varieties in one locality.

Make a collection of pine cones and twigs and distinguish between white, yellow, red, Scotch, and pitch pine, by length, form, arrange-

ment of needles and nature of cones. Make collections of nuts that have been used as food and notice where they have been opened, and compare hardness of shells.

The fruit trees are studied in the third grade in connection with birds and insects and birds showing interdependence of animal and plant-life, in the distribution of pollen and seeds in return for honey and fruit. Also in connection with the study of amber and gums in which insects have been imprisoned showing difference between extinct and extant species.

The willow and sycamore are trees which grow best near streams, and should be taken in connection with swamp vegetation. The poplar and willow show marked difference between drooping and erect branching. Compare protection of buds and development of catkins.

In the early years of a child's school life, most of the work should be devoted to instilling into his soul an interest and love for trees, but when he reaches the fifth grade he should begin to appreciate their utility; the factor they have been in civilization. Compare the characteristics of different woods and their value for certain purposes. Why should the wood of one tree be used for the mast and another for the keel of a vessel that will weather the fiercest gale, and of another the body of a violin whose vibrations shall thrill the hearts of men.

Relate great forest belts to regions of constant rainfall. Compare growth of same trees under different conditions of climate.

Specimens of ebony, mahogany, bamboo, etc., should be compared with pine, oak, etc. Relate to house furnishing and furniture.

A love for trees should be engendered and a sentiment against the great destruction of forests aroused. When possible have trees planted, and others cared for by destroying harmful insect life infesting trees.

Some experiments can be made showing something of the physiology of plants. Some very valuable suggestions may be found in "Botany," for June, in "Nature Study," by W. S. Jackman.

Outline from "Trees of North America," by Apgar. Read "Under the Trees," by Hamilton R. Mabie.

As forest products rank next to agricultural products, children should be led to have a proper appreciation of the care and development of forests and their relation to soil and climate.

I. Formation of Forests.

1. Choice of Species.

2. Reclamation of Soil.

(a) Irrigation.

(b) Drainage.

- (c) Fixation of soil.
 - (1) Mountain sides.
 - (2) Treatment of gullies.
 - (3) Eroded land.
 - (d) Fixation of shifting sand.
 - (e) Treatment of indurated and heavy soil.
3. Formation of Forests by
- (a) Direct sowing.
 - (b) Cuttings.
 - (c) Planting.
4. Formation of Nurseries.
- (a) Select good seed.
 - (b) Mother tree of good condition and age.
 - (c) Germinating beds in good condition.
 - (d) Young seedlings, just enough light.
 - (e) Shade-enduring and light-demanding.
5. Natural Regeneration of Forests.
- (a) Mother trees.
 - (b) Shelter woods.
 - (c) Adjoining woods.
 - (d) Coppice.

II. Influence of Forests upon Water Flow.

1. Rainfall.

- (a) Deposition on foliage, trunks, under floor.
- (b) Reduction of progress of erosion, wash.
- (c) Prevention of formation of shifting sands.

2. Drainage.

- (a) Surface drainage changed to subsoil drainage.
- (b) Porous soil absorbs rainfall.
- (c) Time element in "run off" prolonged.
- (d) Force and rapidity of surface waters reduced.

3. Snow.

- (a) Distribution of snow masses more even.
- (b) Melting of snow under forest cover prolonged.
- (c) Spring floods reduced.

4. Floods.

- (a) Large floods dependent upon cosmical and local terrestrial causes.
- (b) Large floods modified by
 - (1) Topography of land.
 - (2) Character of the soil.
 - (3) River systems.
 - (4) Forest cover.

5. Modifying Influence of Forests.

- (a) Prolongs time of "run off."
- (b) Reduces water stages.
- (c) Reduces extremes of drought and flood.
- (d) Reduces extremes in low and high temperature.

6. Condition of Forest Floor.

- (a) More important in influence upon soil conditions and water flow than trees.
- (b) Forest fires destroy litter.

7. Regulation of Water Supply.

- (a) Relation of water supply to agriculture.
- (b) Relation of forests to conservation of water.

8. Sanitary Influences.

- (a) Reduction in extremes of temperature.
- (b) Reduction of severity of winds.
- (c) Comparative freedom from microbes.
- (d) Injurious lack of rapid evaporation on poorly drained soil.
Southern swamps.

9. Relation of Agriculture to Forestry.**III. Enemies of Forests.****1. Man.**

- (a) Destructive lumbering.
- (b) Excessive taxation on forest land.
- (c) Devastated lands revert to State.

2. Animals.

- (a) Grazing.
 - (1) Destruction of young trees.
 - (2) Fires—burning soil cover improves grass.
 - (2) Fires extend area of pasturage.
- (b) Trampling.
 - (1) Compacting of soil.
 - (2) Destruction of young trees.
 - (3) Destruction of forest floor.
 - (4) Interference with water flow.
 - (5) Formation of flood.
 - (6) Denudation of mountain sides.

3. Insects.**4. Fungi.****5. Wind.****6. Snow.****7. Fire.**

(a) Causes.

- (1) Negligence—hunters.
- (2) Lightning.
- (3) Malice.
- (4) Berry pickers and herders.

(b) Effects.

- (1) Destruction of certain species; weak perish first.
- (2) Destruction of species after species.
- (3) Change in physical condition of surface of earth.
- (4) Plains and prairies largely due to fire.
- (5) Destruction of organisms at work in soil—earth worms, bacteria, moulds, insects.
- (6) Equilibrium in nature destroyed.

IV. Some Important Forest Trees.

White pine,	Red juniper,
Sugar pine,	Arbor vitae,
Cuban pine,	Big-tree,
Balsam fir,	Swamp white oak,
Noble fir,	Beech,
Hemlock,	Black walnut,
Tamarack,	Pecan,
Tulip tree,	White cedar,
Sugar maple,	Redwood,
White elm,	White oak,
Basswood,	Bur oak,
Cottonwood,	Chestnut,
Long leaf pine,	Shag bark hickory,
Short leaf pine,	Locust,
Black spruce,	White ash,
White spruce,	Red maple,
Douglas spruce,	River birch,
Ball cypress,	Sycamore,
Western larch,	White willow.

OUTLINE FOR DETERMINATION OF MINERALS.

I. Scale of Hardness.

1. Talc and Gypsum. Very soft. Can be scratched with finger nail, or very easily with a knife.
2. Calcite and Fluorite. Soft. Cannot be scratched with finger nail, but easily scratched with knife.

3. Apatite and Orthoclase. Hard. Not easily scratched with knife; scratches glass.

4. Quartz and Topaz. Very hard. Cannot be scratched with knife; scratches glass. Topaz scratches quartz.

5. Corundum and Diamond. Corundum scratched by diamond and itself; diamond not scratched by any other mineral.

II. Specific Gravity.

1. Weight in air.

2. Weight in water.

3. Specific gravity—weight in air; loss of weight in water.

III. Form.

1. External. Surface—grape like. Porous—mineral incrustations formed from solutions. Stalactitic—hanging from under surface of rock, cone-shaped. Stalagmitic—formed on floors of caverns from dripping water. Stratified—deposited in layers.

2. Internal. Granular, coarse or fine—small crystals. Compact—crystals invisible to unaided eye.

IV. Tenacity.

1. Brittle—breaks easily.

2. Malleable—flattens into thin sheets under hammer.

3. Sectile—may be cut into thin slices.

4. Flexible—retains its form when bent.

5. Elastic—comes back in its original form when bent.

V. Lustre.

1. Metallic, as in Metals.

2. Non-metallic—vitreous, as in glass. Pearly, as in pearl. Resinous, as in sulphur, sphalerite, resins. Pitchy, as in cannel coal. Silky or satiny, as in satin spar. Greasy, or waxy, as in serpentine. Dull, as in chalk.

VI. Streak.—Color obtained by rubbing mineral over surface of a piece of ground glass or file.

VII. Diaphaneity.

1. Transparent, semi-transparent.

2. Translucent, sub-translucent.

3. Opaque.

VIII. Acid Tests. Use H. Cl. (hydrochloric acid) or dilute H_2SO_4 (sulphuric acid), or both. Use a little of the mineral in a test tube.

1. Insoluble.

2. Soluble. With effervescence, with or without heat. Without effervescence, with or without heat.

IX. Flame Tests. Use a fine splinter of the mineral, or thin edge in the flame of an alcohol lamp or bunsen burner. Note color imparted to flame.

1. Fusible—melts.
2. Infusible—does not melt.
3. Decrepitates. Breaks into small pieces with crackling sound.
4. Intumescens. Swells up without fusion.

Taken from "Nature Study," by W. S. Jackman.

GERMINATION OF SEEDS.

I. Function of Life to Reproduce Itself.

II. Environment and Activity of a Plant Directed Toward Producing Seed.

A SEED.

- I. Outer parts: hilum or scar-point of attachment; micropyle—opening near hilum. Seed-coats; outer—testa; inner—tegmen.
- II. Inner parts: cotyledons—thickened leaves in which nourishment is stored. (a) Dicotyledons—two. (b) Monocotyledons—one.

Plumule—small terminal bud; caulicle or radicle—small stem within seed-coats.

Embryo—plantlet.

Seed,	I. Dicotyledon.	II. Monocotyledon.
Venation,	Netted.	Parallel.
Wood,	Ringed.	Fibrous.
Flower,	Fives.	Threes.
	I.	II.
	Bean.	Corn.
	Pea.	Wheat.

III. Plant Seeds under Different Conditions.

- (1) Light, shade, dark.
- (2) Sand, clay, gravel, loam.
- (3) Dry, moist, damp.
- (4) Hot, warm, cold.

IV. Development of Plantlet.

- (1) Bursting of seed-coats.
- (2) Plumule into stem.
- (3) Radicle into root.
- (4) Cotyledons that are leaf-like.
- (5) Cotyledons not leaf-like.

- (6) Those that grow above ground.
- (7) Those that do not grow above ground.

NOTE.—Record accurately the date of planting, first appearance of plant, first leaves, second leaves, etc. Press and mount plants showing development during two or three days.

SIXTH GRADE.

PLANTS.

Earth, air, and water play such an important part in the development of plants it is well for the children to have some simple experiments which will show how some of the work is done.

OSMOSIS.

1. Experiments.

- (a) Place some thin slices of red beet, carrot and turnip in a vessel of fresh water, in a 5 per cent. salt solution, and in strong sugar solution. Examine after a few hours. Remove slices from salt solution and sugar solution, wash, and place in fresh water. Compare results.
- (b) Treat bean and corn seedlings in the same way; leaves of geranium and coleus, allowing petioles to project above liquid.
- (c) Compare stewed prunes and raisins and dried fruit with uncooked.
- (d) Soak cucumbers in strong salt water; in fresh water.
- (e) Tie tightly a piece of bladder membrane over the large end of an argand lamp chimney. Place a strong solution of sugar—two parts sugar and one part water—in the chimney, allowing it to extend partway up the chimney. Immerse in water in a wide-mouthed vessel, having both solutions on the same level. Support chimney by means of corks. Note change in level of liquids. What is the direction of greatest flow?
- (f) Use same apparatus. Change liquids. Color fresh water in chimney. What is the direction of greatest flow?

2. Absorption of Liquid Nutriment.

Roots are composed of cells. Cell sap more dense than soil moisture; flow of soil moisture through protoplasmic lining of cell wall; cell sap diluted; cell sap of next cell dense, diluted sap flows toward denser sap and so on until large ducts are reached.

Plant peas, beans, corn or buckwheat in soil, distilled water, and

undistilled water. The water cultures can be set up by tying a thin piece of cotton over the top of a glass jar and germinating the seed on it. Note the time they grow equally well and give reason, and any difference afterwards.

Germinate a few seeds between blotting paper, and apply blue litmus paper. Acid property of root hairs sets free chemical compounds of potash, phosphoric acid, etc., which are deposited in the soil and not soluble in water. Germinate seeds in shells.

3. Wilting of Plants.

- (a) Remove leaves from a geranium or coleus; place some in open air and others under a glass. Examine in a few hours. Put a branch in a jar of water with top exposed to air, and one with top covered. Note any difference in twenty-four hours.
- (b) What enables tender, succulent shoots to stand erect?
 - (1) Remove successively strips from the petiole of a rhubarb leaf six inches long. Note the effect. Replace the strips. What do you notice?
 - (2) Cut a transverse section half an inch in length from a willow shoot an inch in diameter. Remove the bark. Try to replace it.

4. Root Pressure.

Observe sap exuding from pruned branches and vines in spring.

Root pressure in nettle sufficient to hold a column of water fifteen feet; in vine, sufficient to support a column of water 6.5 feet; in birch, sufficient to support a column of water 84.7 feet.

Experiment to demonstrate root pressure.—A plant in the open may be used or a plant grown in a pot. Cut the stem two inches from soil. Connect a long glass tube of small bore and the cut stem in the soil with a short piece of rubber tubing. Moisten end of stem. Support the glass tubing. Observe the water rising in the tube. Does it rise continuously or rise and fall?

TRANSPIRATION OF MOISTURE.

1. Experiments.

- (a) Place a handful of fresh, green, succulent leaves with dry surfaces under a glass jar and place in light or sunlight. Set up another jar in exactly the same way but containing no leaves. In six hours compare results.
- (b) Cover the surface of the soil of an actively growing plant, in a pot, with a sheet of rubber cloth, to prevent evaporation. Cover with a bell jar and place in the sunlight.
- (c) Take a young oak, maple, or peach tree. Cut a slit from the circumference to a small hole in the center of a circular

piece of cardboard. Slip the stem of the plant through slit to the small hole. Seal the opening around the stem and the opening to edge of cardboard. Place the cardboard over a wide mouthed jar, allowing the roots to extend into water. Cover part of plant above the circle with a jar and seal. Compare amount of water given off with leaf area. Estimate amount of water given off by a tree, a forest, a field of corn or wheat.

- (d) Immerse geranium, coleus, some seedlings in hot water. Another set in cold water. Spread out in a dry room. Make repeated comparisons during the day. Results.

PATH OF LIQUIDS IN PLANTS.

1. Experiments.

- (a) Insert the cut ends of a leafy shoot in colored water—nasturtium, "touch-me-not," caladium, corn, horse-chestnut. Note appearance of leaves. Make a cross section and longitudinal section of the stem. Try different plants. In how many are the colored areas in a circle? In how many are they scattered irregularly? Associate arrangement of fibre, vascular bundles, with structure of seed monocotyledons and dicotyledons.

RESPIRATION OF PLANTS.

- (a) Put some peas soaked from twelve to twenty-four hours in a pint fruit jar. Keep in a warm place securely sealed for twenty-four hours. Remove cover and quickly pour into jar some lime water and seal again. Note precipitation of calcium carbonate.
- (b) Burn a splinter or candle in a jar, forming carbon di-oxide. Pour in lime water. Note precipitation of calcium carbonate.
- (c) Through a tube, blow your breath into some lime water. Note precipitation of calcium carbonate.
- Compare respiration of plants and animals.

CARBON FOOD OF PLANTS.

- (a) Test corn starch with iodine to get the well known reaction for starch; cut a potato and scrape the cut surface into a pulp; beans; corn.
- (b) Test leaves that have grown in light; in dark; seedlings. First remove chlorophyll by boiling in alcohol.

- (c) Cover the upper and under surface of a part of a leaf with a piece of cork and place in sunlight. Next day remove cork and test leaves for starch.
- (d) Give a reason why the upper surface of leaves is always turned to the light. Note shape and arrangement of leaves with relation to sunlight.

GROWTH OF PLANTS.

1. Growth of Roots.

(a) Germination.

Soak peas, beans, corn, squash, pumpkin, etc., for twelve hours; place between folds of paper or cloth; keep moist and warm.

(b) Pumpkin.

When radicle or first root is a quarter of an inch in length; beginning with the tip, mark off sections one-sixteenth of an inch in length. Keep moist and warm. Determine the growing part of root.

2. Growth of Stem.

Embryo develops into root, stems and leaves. Nodes are enlargements at the juncture of the leaves with the stem; internodes, spaces on stem between successive nodes.

- (a) Use a bean or corn seedling. Mark off several internodes into sections one-sixteenth of an inch apart. Note region of greatest elongation. Compare growth of root and stem.

IRRITABILITY.

1. Influence of Earth on Direction of Growth.

- (a) Pin germinating peas, beans, or squash seeds marked off as above, on a large cork in such a position that one may be horizontal, one in a normal position, one in inverted position. Keep moist and warm. What changes do you observe? What is the region of greatest activity.
- (b) Remove tip of roots of other seedlings and place on corks as above. Contrast the two experiments.
- (c) Turn pot containing germinating seedlings over on the side. Note effect.

2. Influence of Light.

- (a) Plant seeds in dark, shade and light.
- (b) Subject seedlings to one sided illumination.
- (c) Put growing seedlings in a dark chamber with small opening.

3. "Sleep of Plants."

- (a) Folding of leaves—clover, oxalis, lupine, acacia. Note manner of folding.
- (b) Seedlings—cotyledons fold up and leaves down.
- (c) Upper surface of leaves avoids zenith at night to prevent radiation of heat.

4. Movement, Result of External Stimuli.

- (a) Twining stem of dodder.
- (b) Tendrils of grape, flowering cucumber, sweet pea.
- (c) Leaves of sensitive plant, Venus fly-trap, drosera.

BIRDS.

I. Relation of Birds to Man.

1. Scientific—Type of Animal Kingdom.

2. Economic—Service Rendered.

- (a) Checking increase of insects.
- (b) Devouring small rodents.
- (c) Destroying seeds of harmful plants.
- (d) Acting as scavengers.

3. Aesthetic—Appreciation of Birds.

- (a) Beauty of form and plumage.
- (b) Grace of motion.
- (c) Power of song.
- (d) Habits of life.

II. Outline for Identification.

1. Size—Compare with Sparrow or Robin.

2. Color.

- (a) Attractive—oriole, cardinal, tanager.
- (b) Protective—song sparrow, quail, creeper.

3. Markings.

- (a) Top of head—kinglet, chickadee.
- (b) Back—oriole, bobolink.
- (c) Breast—kingfisher, plover.
- (d) Wings—golden-winged woodpecker, night hawk.
- (e) Tail—meadow lark, king bird, cedar bird.

4. Shape.

(a) Body.

- (1) Long and slender; short and thick.
- (2) Relation of shape to habitat—earth, air and water.

(b) Bill.

- (1) Short and stout; long and slender; long and heavy; slender and delicate; hooked; curved; crossed.

- (2) Relate shape of bill to food and manner of getting it.
- (c) Wing.
- (1) Short and round; long and slender.
- (2) Relate shape of wings to flight, food, and development of feet.
- (d) Tail.
- (1) Square; notched; fan-shaped; graduated; pointed for bracing; long and forked for steering; short and tipped with spines for bracing.
- (2) Relate shape of tail to food getting.
- (e) Feet.
- (1) Weak; strong; webbed.
- (2) Compare feet and legs of divers, swimmers, waders, scratchers, climbers, perchers and birds of prey.
- (f) Movements.
- (1) Hopping, walking, creeping, climbing, flying, wading, diving, swimming.
- (g) Flight.
- (1) Rapid—direct, abrupt and zigzag; smooth and circling.
- (2) Slow—flapping; sailing and soaring; flapping and sailing alternately; oblique flight; undulatory flight.
- (3) Relate flight to food getting.

III. Parts of a Bird.

1. Head.

- | | |
|------------------------------|------------------------------|
| (a) Culmen. | (k) Circum auricular region. |
| (b) Upper mandibles. | (l) Ear coverts. |
| (c) Lower mandibles. | (m) Cheek. |
| (d) Forehead. | (n) Side of Neck. |
| (e) Crown. | (o) Jugulum. |
| (f) Occiput. | (p) Throat. |
| (g) Nape. | (q) Chin. |
| (h) Eyes. | (r) Submaxillary line. |
| (i) Circum orbicular region. | (s) Gape. |
| (j) Ear. | |

2. Body.

- | | |
|---------------------------|-------------------------|
| (a) Back. | (f) Tail feathers. |
| (b) Interscapular region. | (g) Lower tail coverts. |
| (c) Scapulars. | (h) Abdomen. |
| (d) Rump. | (i) Breast. |
| (e) Upper tail coverts. | (j) Sides. |

3. Wings.

- | | |
|-------------------------|---------------------------|
| (a) Primary feathers. | (d) Greater wing coverts. |
| (b) Secondary feathers. | (e) Middle wing coverts. |
| (c) Tertiary feathers. | (f) Lesser wing coverts. |

4. Legs.

- | | |
|-------------------|-----------------|
| (a) Tibia. | (e) Middle toe. |
| (b) Tarsus. | (f) Outer toe. |
| (c) Carpel joint. | (g) Inner toe. |
| (d) Hind toe. | |

IV. Bird Music.**1. Songs.**

- (a) Character of song.
- (b) Call notes; alarm calls.
- (c) Manner and time of singing.

2. Sexual Differences in Song.

- (a) Compare notes of male and female.
- (b) Relate color to song.

V. Color of Birds.**1. Variation of Color.**

- (a) With age—robin, bobolink.
- (b) With seasons—tanager, snow-bunting.
- (c) During moulting and wearing off of feathers.

2. Color in Relation to Haunts and Habits.

- (a) Protective—against enemies—quail, sparrow.
- (b) Deceptive—to prey—owl, hawk.
- (c) Attractive—in harmony with leaves and flowers—oriole, humming bird, warbler.

3. Sexual Differences.

- (a) Tanager, bobolink, peacock, pheasant.

Read "The Law Which Underlies Protective Coloration," in "The Auk," New York City, Vol. XIII, p. 124.

4. Relation of Color to Nesting Habits.

- (a) Location.
 - (1) Ground—meadow lark, song sparrow.
 - (2) Trunks of trees—woodpeckers; holes—bluebird.
 - (3) Branches—robin, cat bird.
 - (4) Pendant from branch—oriole.
 - (5) Banks—bank swallow, kingfisher.

5. Form of Nest.

- (a) Open nests—thrushes.
- (b) Pocket shaped—oriole.
- (c) Basket shaped—vireo.
- (d) Dome shaped—oven bird.
- (e) Wall pocket shaped—chimney swift.

5. Relation of Color to Song.

- (a) Dull color—generally beautiful song—song sparrow, thrushes, vireo.
- (b) Brilliant colors—usually unpleasant notes—peacock, woodpecker, humming bird.

VI. Food.

1. Kinds of Food.

- (a) Weed seeds, fruit.
- (b) Animal—eggs, larvae, pupae, insects; birds; fish; mice and rats.

2. Manner of Obtaining Food.

- (a) On the wing.
- (b) With call of warning.
- (c) In wait for prey.
- (d) On prey without warning.

VII. Insect-Eating Birds.

1. Potato Beetle.

Rose-breasted grossbeak, cuckoo, quail, hairy woodpecker.

2. Tent Caterpillar.

Crow, chickadee, oriole, red-eyed vireo, yellow-billed cuckoo.

3. Cutworms.

Robin, crow, cat bird, house wren, meadow lark, cow bird.

4. Ants.

Catbird, thrasher, house wren, woodpecker.

5. Scale Insects.

Woodpeckers, cedar bird, bush-tit.

6. May Beetle.

Hermit thrush, robin, meadow lark, brown thrasher, blue-bird, cat bird, blue jay.

7. Weevils.

Crow, crow blackbird, red-winged blackbird, Baltimore oriole, cat bird, cow bird, scarlet tanager.

8. Chinch Bug.

Brown thrasher, meadow lark, cat bird, red-eyed vireo, robin, bob white.

9. Wire Worm.

Red-winged blackbird, crow blackbird, crow, woodpecker, brown thrasher, cat bird, scarlet tanager, oriole cow bird.

10. Crane Flies.

Robin, cat bird, wood thrush, crow, crow blackbird, red-winged blackbird.

11. Cotton Worms.

Bluebird, blue jay, red-winged blackbird, thrushes, prairie chicken, quail, kilden, bobolink, cardinal.

12. Gypsy Moth.

Yellow-billed cuckoo, black-billed cuckoo, hairy woodpecker, downy woodpecker, king bird, great-crested fly-catcher, Phoebe, wood pewee, blue jay.

13. Grasshoppers and Crickets.

Mocking bird, thrasher, bluebird, wren, shore lark, goldfinch, song sparrow, junco, rose-breasted grosbeak, cardinal, bobolink, cow bird, blue jay.

14. Army Worm.

King bird, Phoebe, bobolink, cow bird, Baltimore oriole, robin.

VIII. Nesting Habits of Birds.**1. Location of Nests.**

- (a) Land birds.
- (b) Water birds.
- (c) Aerial birds.

2. Structure.

- (a) Form, size, material.
- (b) Time and method of construction.

3. Eggs.

- (a) Number, color, markings.
- (b) Time of incubation.

4. Care of Young.

- (a) Feeding.
- (b) Teaching to fly.

IX. Migration.**1. Migrative and Breeding Records.**

- (a) Name of bird and order.
- (b) Common name.
- (c) Summer residents.
 - (1) Date of spring arrival.
 - (2) Date of fall departure.
- (d) Winter residents.
 - (1) Date of fall arrival.
 - (2) Date of spring departure.

2. Breeding Records.

- (a) Date of laying of eggs.
- (b) Number of eggs.
- (c) Time of incubation.
- (d) Number of young hatched; reared.

3. Occurrence.

- (a) Abundant.
- (b) Common or rare.
- (c) Number at different seasons.

1. Locality.

(a) Where observed.

(b) Character of immediate vicinity.

(1) Gardens and orchards—oriole.

(2) Lanes and highways—song sparrow.

(3) Open meadows—meadow lark.

(4) Thickets of undergrowth—thrush.

(5) Dense woods—hermit thrush.

(6) Rivers and lakes—kingfisher, snipe.

(7) Marshes—marsh wren, bittern.

X. Classification.

1. Orders and Families Based Upon.

(a) Skeletal.

(b) Muscular.

(c) Visceral.

2. Genera—External Characteristics.

(a) Bill, feet, wings and tail.

3. Species and Sub-Species.

(a) Color and size.

XI. Key to Orders.

WATER BIRDS.

A. Divers.

Order I. Pygopodes.

Grebe, loon, auk.

Order II. Longipennes—long-winged.

Gull, tern.

Order III. Tubinares.

Albatross, petrel.

Order IV. Steganopodes.

Gannet, cormorant, pelican.

B. Swimmers.

Order V. Anseres—swimmers.

Duck, goose, swan.

C. Waders.

Order VI. Odontoglossae.

Flamingo.

Order VII. Herodiones.

Heron, stork, ibis.

Order VIII. Paludicolae.

Crane, rail.

SHORE BIRDS.**Order IX. Limicolae.**

Phalarope, snipe, plover.

LAND BIRDS.**Order X. Gallinae—scratchers.**

Turkey, grouse, quail.

Order XI. Columbæ.

Pigeon, dove.

Order XII. Raptores—birds of prey.

Vulture, hawk, owl.

Order XIII. Psittaci.

Parrot, paraquet.

Order XIV. Cocyges.

Cuckoo, kingfisher.

Order XV. Pici.

Woodpecker.

Order XVI. Machrochires.

Goat sucker, swift, humming bird.

Order XVII. Passeres—perches.

Flycatcher, bluebird, blue jay, oriole, sparrow,
finch, swallow, vireo, warbler, wren, thrush.

The work on birds has been outlined very much in detail, simple enough to be of use to the most casual observer, and comprehensive enough to be of value to pupils who wish to go more deeply into the subject. It should ever be borne in mind that the chief aim of this work is to stimulate the effort and enthusiasm of the individual pupil. Very effective work can be accomplished by having each pupil select a pair of birds, and make them the object of his especial attention, comparing them with other birds of the same species and order. An interest in one bird is a stepping stone to a knowledge of many birds.

Encourage children to make boxes and nesting places for birds; to supply them with food during any stress of weather; to attempt to tame wild birds; to photograph birds from life. Discourage all egg collecting and desire for a collection of stuffed birds. Make the living, moving, singing bird the object of supreme interest.

Classification taken from "Handbook of Birds of Eastern North America," by Frank M. Chapman.

MINERALS.

After making observations of the rock structure of the earth and its relation to animals, plants and soil, it is important for the children to become acquainted with some of the most common minerals—their characteristics, composition and weathering products.

A mineral may be defined as a homogeneous solid, of definite chemical composition, occurring in nature, but not of apparent organic origin.

I. Minerals.

1. Mixtures.

Granite, quartz, mica and feldspar.

2. Compounds.

Quartz—silicon and oxygen.

3. Elements.

Oxygen, gold, mercury.

An element is a substance which cannot be reduced into other elements; silver, gold.

4. Important Elements in Earth's Crust.

(a) Gaseous.

Oxygen, hydrogen, nitrogen, chlorine.

(b) Liquid.

Mercury.

(c) Solid.

Silicon, aluminum, iron, calcium, magnesium, potassium, sodium, carbon, phosphorus, sulphur.

5. Important Minerals in Earth's Crust.

(a) Quartz.

Flint; hornstone; white, brown, yellow or black pebbles, uniform in color; sand; amethyst; false topaz; smoky quartz; cairngorm stones; agate, cornelian.

(b) Silicates—rocks containing silica.

Feldspar, mica, hornblend, augite or pyroxene, garnet, serpentine, chlorite, tourmaline, olivine.

(c) Carbonates—compounds of carbonic acid.

Calcite—calcium carbonate; magnesium limestone or dolomite.

(d) Sulphates—compounds of sulphuric acid.

Gypsum—sulphate of lime; barite—barium sulphate; copperas or green vitriol—iron sulphate.

(e) Ores—metal bearing minerals.

Iron pyrites; chalcopyrites or copper pyrites; magnetite or magnetic iron ore; hematite or specular iron ore; limonite—brownish yellow iron ore; siderite or spathic iron ore; chalcopyrites, or yellow copper ore; galenite, or lead ore; malachite—green copper carbonate; azurite—blue copper carbonate.

II. Kinds of Rock.

1. Calcareous.

Limestone; magnesium limestone; chalk; marble.

2. Silicious.

Sandstone—dull, gray, brown, brownish-red and red.

3. Conglomerates.

Mass of smooth, rounded fragments, cemented in a matrix; limestone, shell, quartz-pebble, granite-pebble, and volcanic conglomerates.

4. Shale.

Shale—consolidated fine sand, mud or clay; color, gray, yellowish, brown or black. Black most common, due to organic remains of animals and plants.

5. Argillaceous Sandstone.

Consolidated clayey beds of sandstone, which usually break into thin slabs, flagstones for sidewalks.

6. Slate.

Structure fine and firmer than shale. Splits easily and evenly. Used for roofing.

7. Granite.

Composition—quartz, feldspar, mica, mixed promiscuously together. Quartz, grayish or smoky in color, no cleavage; feldspar—white or flesh-red, good cleavage, sparkling faces in sun; mica—white, brownish or black, perfect cleavage; quartz and feldspar hard—mica soft.

8. Gneiss.

Same constituents as granite, but arranged in planes; owing to cleavage of mica, rock splits into layers.

9. Mica Schist.

Constituents same as granite and gneiss—mica and quartz most abundant; divides into thin layers. No dividing line between granite, gneiss and mica schist.

10. Syenite.

Granite-like rock, mica replaced by hornblend; little or no quartz.

11. Trap, Basalt, Lavas or Volcanic Rocks.

Igneous rocks, cooled from fusion.

III. Structure of Rocks.

1. Stratified Rock—layers piled one upon another.

(a) Sandstone.

(b) Limestone.

(c) Shale.

(d) Slate.

2. Unstratified Rock—not made up of layers.

(a) Granite.

(b) Trap.

IV. Making of Rock.**1. Igneous Rocks—formed from fusion.**

(a) Holocrystalline—coarse grained; granite.

(b) Crytocrystalline—fine grained; obsidian.

2. Sedimentary Rock.

(a) Deposition from solution.

(1) Stalactites or stalagmites in caves.

(2) Calcareous tufa.

(b) Mechanical agency of water.

(1) Fragmental rock—parts of older rocks.

(2) Shales, slates, sandstone and conglomerates.

(c) Organic remains.

(1) Limestone—corals, shells, crinoids, and foraminifera.

(2) Silicious deposits—plants—diatoms; animals—radiolarians; sponges.

(d) Making of peat beds.

(1) Deposit of leaves, stems, and remains of plants.

(2) Growth and death of sphagnum moss.

(3) Remains of animals.

(e) Work of streams.

(1) Abrasion of stream bed and banks.

(2) Transportation of material in suspension and solution.

(3) Deposition of detritus. Depends upon volume and velocity of stream.

(f) Work of heat.

(1) Expansion and contraction from change of temperature.

(2) Formation of rock by fusion.

(g) Cementing of rocks by

(1) Carbonate of lime; limestone, clay and sandstone.

(2) Iron; sandstone.

(3) Silica; sandstone.

(h) Metamorphosis.

(1) Change in texture—limestone to marble.

(2) Rearrangement of material—granite to gneiss.

PHYSICS.**WATER.**

- (a) Properties—liquid, clear, colorless, transparent, tasteless, odorless, cannot be compressed into smaller space, presses in all directions equally.

- (b) Relation—to animals, plants, soil, and medium for transportation.

1. Pressure of Liquids.

- (a) Presses downward and sideways.

With a nail make a row of holes near the bottom of a baking powder can; fill with water. Compare streams issuing from holes. Make a row of small holes and row of larger holes down the side of a similar can; fill with water. Compare streams from three sets of holes.

- (b) Pressure upward and in every direction.

- (1) Press glass down in a vessel of water.

- (2) Partly fill a jar with water; float a circular piece of cardboard on the surface of the water. Place the large end of an argand lamp chimney on the card and press down. What supports the card? Carefully pour water into the chimney. Compare the height of the water in chimney and jar when the card floats away.

- (c) Buoyancy of liquids.

- (1) Buoyancy of water.

- (a) Corks in water; buoys; life boats, preservers.

- (2) Buoyancy of salt water.

- (a) Learning to swim in fresh and salt water.

- (b) Put an egg in a jar of water; it sinks. Why? Through a tube or funnel pour strong salt water to the bottom of the jar. What makes the egg change position? Stir the water. What causes the egg to rise to the top?

- (3) Buoyancy of mercury, salt and fresh water.

- (4) Specific gravity.

- (a) Floating vessels and icebergs.

- (b) Oil on water; cream on milk.

2. Water as a Solvent.

- (a) Action on salt, sugar, alum, soda, etc.

- (b) Uses of water dependent upon solvent power.

- (1) Formation of caves and springs.

- (2) Assimilation of minerals by plants.

- (3) Lime in solution in ocean and rivers used by coral and shell animals.

3. Water as Vapor.

- (a) Evaporation. Effect of heat upon evaporation; heat at different times of day; seasons; zones.

- (b) Condensation. Fog, mist, clouds, rain, steam. Relations. Effect of cold upon vapor. Condensation in different latitudes and altitudes.

- (c) **Snow and ice.** Compare snow, ice and water. Meaning of frozen. Compare, snow, ice and hail. Uses of snow and ice. Relations.

Snow a warm covering for plant and animal life, poor conductor of heat, prevents radiation of heat. Ice a protection to fish in rivers and lakes.

ATMOSPHERIC PRESSURE.

1. Air Presses Equally in all Directions.

- (a) Fill a glass with water. Press a blotter down on the top of it; invert the glass; turn in all directions. What causes the blotter to remain?
- (b) Cut a circle from a soft piece of leather; draw a cord through a hole in the center, making it air tight; wet the leather; press it on a slate or smooth stone, forcing all the air out. Suspend slate by the string. What prevents it from falling?
- (c) Boil an egg hard. Remove the shell. Heat a bottle whose opening is almost the size of the egg. Put the egg in the opening and put in a cool place. What forces the egg into the bottle?
- (d) Weigh a corked test tube filled with air. Remove the cork and heat the test tube. Recork while hot and weigh. What caused the difference in weight?
- (e) Fill a glass tube closed at one end with water and place open end under the surface of a vessel of water. What supports the column of water?

2. Variation of Pressure.

- (a) Altitude.
- (b) Latitude.
- (c) Amount of vapor contained. Consult barometer.

3. Pumps.

Relation of pressure of atmosphere to lifting pump. Construction, action and uses of lifting pump. Windmills.

Relation of pressure, compressibility and elasticity of atmosphere to force pump. Uses of force pump.

4. Siphon.

Formation of siphon, action, uses. Conducting water, emptying casks, etc., flow of springs.

HEAT.

Expansion and Contraction.

- (a) Gases—air—wind.

(b) Liquids—water—evaporation—condensation.

(c) Solids—rock—disintegration of rock.

1. Gases.

Experiments.

- (1) Half fill a bladder with air, tie securely, and place in front of the fire. It begins to swell, almost at once, and is soon quite full. Heat expands gases.
- (2) Half fill a rubber balloon with air and tie securely. Place in water and heat gradually. The balloon enlarges. Plunge it into cold water. It becomes smaller. Why? Cold contracts gases.
- (3) Blow thistle down or milkweed pappus over a hot stove or register. They rise. Why? The air is heated, expands, and is forced up by cold currents.
- (4) Observe the direction of sparks, smoke and cinders of a bonfire; the disturbance of the leaves around the fire. Account for the result. The air is heated, expands, thus carrying sparks, smoke and cinders. The cold air coming from all sides to replace the heated air, forms currents carrying the scattered leaves toward the fire.

Relate these experiments to absorption and radiation of heat by earth's surface and production of winds.

2. Liquids.

- (1) Fit a glass tubing through a cork. Fill a test tube with colored water. Press in the cork, causing the water to stand in the tube just above the cork. Heat the water. It rises in the tube. Why? Heat expands liquids. Cool the tube. The water falls. Cold causes liquids to contract. Water is the exception. It contracts until it reaches freezing point and then expands. Put a bottle filled with water in a cold place where the water will freeze. What causes the bottle to burst? What causes the rocks to crack in winter? Observe ledges of rocks; do you see any effects of freezing? Observe the upheaval of soil in damp places in winter. What effect does freezing have upon wet, clay soil? What effect does this freezing have upon the disintegration of rock? Relate this disintegration to liberation of plant food in the rock.
- (2) Put one-half pint of water into vessels 4x4x4 inches, 4x8x2 inches, 4x2x8 inches, 4x4x2 inches. Expose to great heat, cold, wind, for twenty-four hours and measure the water in each vessel. Relate the amount of evaporation in the deep and shallow vessels to deep and shallow bodies of water.

Relate the amount evaporated in places of different temperatures to places of different altitudes and latitudes.

Boil a gill of water until all passes off as vapor. Put a gill of water in a plate, a cup, a bottle. Record the length of time taken for the water to evaporate from each vessel. Relate time to amount of heat and surface exposed.

Hold a cold glass in steam. What causes the water to form into drops. Blow your breath on a cold window pane. Breathe deeply in cold air. What causes fogs, clouds, dew, and frost? Relate evaporation and condensation to rainfall.

- (3) Put a thermometer into cold water. The mercury descends in the tube. Heat the water. The mercury ascends in the tube. Why? Heat expands liquids.

3. Solids.

- (1) Fit a marble into a steel or iron ring. Heat the ring. The marble falls through. Why? Heat causes solids to expand. Cool the ring; the marble cannot fall through. Why? Cold causes solids to contract.
- (2) Take a bar of iron which exactly fits into a hole. Heat the bar; it will no longer pass through. Why?

4. Questions.

- (1) Why does boiling water raise the tea-kettle lid?
- (2) Why does a hot lamp chimney break when a drop of cold water falls upon it?
- (3) Why is the tire of a wheel fitted while it is hot? Why is cold water then poured upon it?
- (4) In laying rails for a railroad why are the ends not fastened together.
- (5) Why do chestnuts burst open with a loud report when they are roasted?
- (6) Why does a punching ball become soft in the cold air when it was firm in a warm room?
- (7) Would the tires of a bicycle be firmer on a cold day or a warm day?

SEVENTH GRADE.

The great majority of pupils never reach the high schools, colleges, or universities. They should be given some idea of the relation of

minerals, plants and animals in time and space. Type specimens of animals and plants should be studied to show the natural order of development. These should be compared, as far as possible, with fossil species in the rocks. It will be shown that the higher types have evolved from the lower, and that development or evolution can be traced vertically in the rocks, and horizontally in existing species.

The relation between the animal, vegetable and mineral worlds should be emphasized. Much of the work in this grade is organizing and relating work done in lower grade.

The following lessons are suggested hoping that an interest may be aroused in minerals, and a desire to read the wonderful story graven in rocks during past ages. It is sincerely hoped that a collection of specimens will be secured for every school. No neighborhood will supply all varieties. An exchange may be effected between different parts of the State. The bulletin of the American Bureau of Geography, published at the State Normal School, Winona, Minn., has a bureau for the exchange of geographical supplies. The most useful material is that which is secured by the individual pupil, during visits to quarries, bluffs, mines, in his vicinity. Each geographical situation has its own history and interest. Are the rocks igneous or sedimentary; stratified or not; horizontal, tilted or folded; result of mechanical, chemical, or organic agencies. Collect fossil plants, animals and minerals. Observe effects of a heavy rain storm—gullied hillsides and roads; flood plain, water falls, precipices, cataracts. All the conditions of a great river drainage system may be found in one of these miniature areas. As all continents are made up of adjoining drainage areas, the same land and water forms exist everywhere, modified by altitude, latitude and local conditions.

The economic side of the study of minerals is important, but the vital thing is that the children shall approach the work with a proper spirit, and an appreciation of the forces necessary to produce a crystal, record the life history of a fern in a piece of coal, or deposit a stratum of rock 40,000 feet in thickness.

Collections of minerals can be secured from Ward's Natural Science Establishment, 18-28 College avenue, Rochester, N. Y.

Edwin E. Howell, 612 Seventeenth st., N. W., Washington, D. C.

A. E. Foote, 1317 Arch st., Philadelphia, Pa.

Nature includes all created things. Nature study is not only the study of all created things but also all the changes which they undergo.

Natural law is the order in which things have been observed to happen; it is immutable; there are no exceptions. The relation of cause and effect is the fundamental law of nature. By comparing the geological forces at work at the present time, with geological effects of the past, causes can be ascribed.

The generally accepted Nebular theory should be given, as a foundation for the work.

1. Nebular Mass.

1. Gaseous State—hot, highly expanded.

2. Composition—elements, in gaseous state.

(a) Elements—about seventy in number.

(1) Gaseous—hydrogen, nitrogen, chlorine, oxygen.

(2) Non-metallic—sulphur and phosphorus.

(3) Metallic—iron, lead, tin, mercury, copper, gold, silver and zinc.

Compounds and Mixtures.	Elements.
Water,	Oxygen and hydrogen.
Air,	Oxygen, nitrogen.
Carbon dioxide,	Carbon and oxygen.
Protoplasm,	Oxygen, hydrogen, nitrogen, carbon and others.

As oxygen, hydrogen, nitrogen and carbon are so widely distributed, at this point children should have some experimental work to become familiar with the properties of these elements.

3. Elements.

(a) Oxygen.

(1) Sources: air, water, animals, crust of earth.

(2) Preparation: potassium, chlorate and manganese dioxide.

(3) Properties: odorless, colorless, tasteless, does not burn, vigorous supporter of combustion.

(4) Experiments: burn in oxygen, splinter; watch spring; sulphur; phosphorus; zinc.

(5) Distribution: destructive agent of air; purifies blood in human system; plants; minerals.

(b) Nitrogen.

(1) Sources: atmosphere, ammonia, animal matter, mushrooms.

(2) Preparation: burning phosphorus in air.

(3) Properties: colorless, odorless, tasteless, does not burn, does not support life, inert.

(4) Distribution: air, soil, plants and animals.

(c) Hydrogen.

(1) Source: water.

(2) Preparation: sulphuric acid and zinc; hydrochloric acid and zinc; decomposition of water by electricity.

(3) Properties: colorless, odorless, transparent, lightest of all bodies, will burn, does not support combustion.

(4) Distribution: water, animals and plants.

(d) Carbon.

- (1) Sources: carbon dioxide in atmosphere, plants, animals, coal, mineral carbonates.
- (2) Preparation: an element in nature—diamond, graphite.
- (3) Properties: diamond—colorless to black, transparent, hardest substance known, refracts light.
Graphite—black, soft, crumbly.

3. Cooling of Nebular Mass.

- (a) Contraction due to radiation of heat.
- (b) Revolution result of contraction.
- (c) Centrifugal force due to revolution.

4. Forces Acting in Nebular Mass.

- (a) Cohesive.
- (b) Gravitative.
- (c) Centrifugal.

Give simple experiments which will illustrate

- (a) Cohesion of gases, liquids and solids.
- (b) Law of gravitation; give illustrations.
- (c) Centrifugal force.

II. Formation of Planets.

Sub-central mass.

Planets.	Satellites.
Neptune,	One.
Uranus,	Four.
Saturn,	Eight; rings.
Jupiter,	Five.
Asteroids,	About 300.
Mars,	One.
Earth,	
Venus,	
Mercury,	

III. The Earth.**1. Cooling.**

- (a) States of matter: gaseous, liquid, solid due to temperature.
- (b) Effect of heat upon gases, liquids and solids.
- (c) Effect of cold upon gases, liquids, solids.

Experiments with heat outlined for Eighth Grade can be used here, and results used in connection with wind, ocean currents, evaporation and condensation, and disintegration of rock.

2. Formation of Earth's Crust.

- (a) Cooling and contraction.
- (b) Formation of igneous rock.
- (c) Formation of water. Hydrogen, oxygen.

- (1) Condensation and evaporation.
- (2) Formation of rain, lakes, rivers, ocean.
- (3) Review oxygen and hydrogen.

3. Igneous Rocks.

- (a) Review lava—granite, contorted gneiss.
- (b) Compare crystalline structure of rocks.

To show that igneous rocks are due to the action of heat, form crystals of different substances. Make a saturated solution of alum, salt, sugar or copper sulphate; pour part of the solution into a saucer, and part over a woollen string suspended in a bottle. Allow the solution in the saucer to cool rapidly and that in the bottle to cool slowly. Observe form and size of crystals. Compare crystals of quartz, calcite, copper pyrites, iron pyrites, etc. Account for difference in size of crystals. Compare size and shape of snow crystals on cold and mild days.

IV. North America.

1. Archaean Rock.

- (a) Granite, gneiss, syenite, hornblende, quartzite.
- (b) Deposits of iron ore.

2. Distribution of Archaean Rock.

- (a) North—northeastern Canada, Adirondacks and Lake Superior region.
- (b) East—north of New England to Georgia.
- (c) West—along ranges of mountains which later became Cordilleras.
- (d) Land areas surrounded by ocean.

V. Erosion.

1. Cause—Chemical and Mechanical Forces at work on exposed Igneous Rock.

2. Effect—Sedimentary Rock.

- (a) Origin of sedimentary rock—igneous rock.
- (b) Position—upon igneous rock.
- (c) Location—around igneous rock.

Review subject of erosion outlined for Sixth Grade.

VI. Appearance of Life.

1. Importance of Fossils.

- (a) Development of animal and plant kingdoms.
- (b) Distribution of animals and plants.
- (c) Climatic conditions.
- (d) Distribution of land and water.
- (e) Comparative age of strata.

2. Conditions for Forming Fossils.

- (a) Remains of plants and animals in water.
- (b) Exclusion of oxygen.
- (c) Deposition of fine sediment.

3. Forms of Fossils.

- (a) Cast or mold.
- (b) Original material.
- (c) Petrification.

4. Incomplete Life Record.

- (a) Few land animals and plants preserved.
- (b) Organisms exposed to oxidation decomposed rapidly.
- (c) Water animals with soft parts leave no trace.
- (d) Fossils destroyed by metamorphism or solution.

VII. Distribution of Land and Water.**1. Maps.**

- (a) Duplicate maps of North America.
- (b) Indicate supposed areas of land and water during geological eras.

2. Hypothetical maps of North America.

- (a) Archæan era.
- (b) Carboniferous period.
- (c) Cretaceous period.
- (d) Tertiary period.
- (e) Glacial and Champlain periods.

These maps can be found in geological works by Shaler, Dana, Tarr.

Children should compare in imagination the life conditions of different geological eras and periods with the present.

They should know that all geological time is divided into four great periods.

1. Archæan—possibly without life.**2. Paleozoic.**

- | | | |
|---------------------|---|-------------|
| (a) Cambrian. | } | Trilobites. |
| (b) Lower Silurian. | | |
| (c) Upper Silurian. | } | Fishes. |
| (d) Devonian. | | |
| (e) Carboniferous. | | |
- Amphibians

VIII. Classification of Animal Kingdom.

	Fossil Forms.	Modern.
1. Protozoans,	Rhizipods,	Amoeba.
2. Radiates,	Radiolarians.	
	Coral,	Coral.
	Crinoids,	Crinoids.
3. Invertebrates,	Sea Urchins,	Star fish, sea urchins.
	Brachiopods,	Clams.
	Ammonites,	Nautilus.
	Dragon Flies,	Insects.
	Trilobites,	Sow bugs.
	Crustaceans,	Crayfish, snail.
4. Vertebrates.		
a. Fishes,	Ganoid,	Shark.
	Perch,	Bass.
b. Amphibians,	Otozoum Moodii,	Frogs.
c. Reptiles,	Ichthyosaurus,	Alligator, snake.
d. Birds,	Archaeopteryx,	Robin.
e. Mammals,	Mastodon,	Elephant, dog, cat, horse, seal, whale.

By comparing fossil and modern forms, a progressive development will be observed.

The different species of ancient and modern life should be related to the work they have done and are doing in rock formation of the world. As mollusks to formation of marble; corals to building of islands.

IX. Classification of Plants.

	Fossil.	Modern.
1. Thallophytes,	Sea weeds,	Algae.
		Fungi.
2. Bryophytes,	Lichens,	Lichens.
	Land plants,	Mosses.
3. Pteridophytes,	Tree ferns,	Liverworts.
	Lepidodendrons,	Ferns.
	Cycads,	Lycopodium.
	Calamites,	Selaginella.
4. Spermatophytes,	Gingko,	Equisetum.
		Evergreen trees.
		Deciduous trees.

FORMATION OF COAL.

I. Conditions of Life.

1. Plants.

- (a) Extensive marshes.
- (b) Luxuriant growth of vegetation.
- (c) Gigantic ferns, club mosses, equisetum, cycads, lepidodendrons.
- (d) Climate tropical.
- (e) Atmosphere humid; laden with carbon dioxide.

2. Animals.

- (a) Crinoids, corals, brachiopods.
- (b) Worms, crustaceans, trilobites.

- (c) Spiders, scorpions, myriopods, land snails.
- (d) Dragon flies, cock roaches, crickets, beetles; no bees, no flowers.
- (e) Sharks, ganoids.
- (f) First terrestrial vertebrates—amphibians.

II. Subsequent Events.

1. Subsidence: Shallow Sea, Unstable.
2. Life Submerged.
3. Deposition of Sediment.
4. Generation of Heat.
5. Metamorphosis of Plants.

III. Stratification of Coal Measures.

1. Successive Layers of Clay and Coal.
2. Layers Vary in Thickness.

MINERAL OIL AND GAS.

I. Deposits.

1. Porous Rock—Trenton Limestone.
2. Reservoir Capped by Impervious Layer of Rock.

II. Origin.

1. Decomposition of Animal and Plant Life, Deposited in Seas and Lakes.
2. Slow Distillation Caused by Pressure and Heat.
3. Hydrocarbons Produced.
4. Hydrocarbons Exist as Gas or Oil.

GLACIAL PERIOD.

I. Glaciated Area of North America.

1. Canada, Greenland.

United States, from Atlantic Ocean west, north of Ohio and Missouri Rivers.

2. Kinds of Glaciers.

- (a) Continental—Greenland.
- (b) Valley—Western United States.
 - (1) Snow fields, accumulation of snow.
 - (2) Neve—granular ice.
 - (3) Ice stream—moving compact ice.

3. Moraines.

- (a) Lateral—a moving talus.
- (b) Medial—formed by union of two lateral moraines.
- (c) Terminal—accumulation at front end.
- (d) Ground—loose rock, material beneath the ice.

II. Work of Glacier.

1. Erosion.

- (a) Grinding of rocks carried and passed over, freeing boulder clay.
- (b) Polishing and striating rocks.
- (c) Wearing of surface contour by moving ice.

2. Transportation.

- (a) On top of ice.
- (b) Embedded in ice.
- (c) Under ice.

3. Deposition.

- (a) Unassorted and unstratified mass of clay and boulders.
- (b) Assorted and stratified sand and gravel left by glacial streams.
- (c) Irregular deposition forming lakes.

In connection with glaciers review evaporation, condensation and snow crystals.

Do you see any evidences of glaciers in your neighborhood—ground rock, scratched boulders, granitic boulders; moraines?

Compare glaciated areas of North America with non-glaciated.

Locate lake regions of North America. What effect did glaciers have on drainage systems, agricultural products of glaciated regions? What element in soil do grains require? What kind of rock supplies it?

Whether the world was made for man or not it was well made for that purpose. This work in geographical nature study is outlined for the purpose of having children see the relation between present and past geographical conditions; that present agricultural, commercial, and industrial progress is dependent upon the mineral deposits, drainage systems, soil and climatic conditions; that nothing is isolated—all nature is a unit.

As a rule very little attention is given to the lower forms of plant-life. They are so abundant and so beautiful they should be studied. The algae can be observed in the aquarium. If possible the threads should be examined with a compound microscope. Puff balls, toad stools, and mushrooms are of great interest and should be studied; some on account of their beauty of coloring, mushrooms because of their value for food. Remove the stem-like structure of a mushroom; put the cap on a piece of white paper, cover with a glass. After a few hours remove the glass and cap and notice the spore print. Lichens can be found on trees, rocks, old fences and on the ground all through the year. Note color, variety, form, fruiting cups. Relate to disintegration of rock and soil formation.

Different varieties of mosses and liverworts should be observed; structure is too difficult to attempt.

Ferns should be carefully studied—they are so abundant and so closely related to the coal period.

Plant.

Parts—roots, underground stem, leaves and sori.

Sori—groups of brown bodies on under side of leaf.

Note location—irregular distribution, regular.

SUN.

The sun is the great power for keeping the machinery of the universe in motion. It should be studied with great diligence. All light, heat, moisture, condition of animals and plants are dependent upon the relative positions of earth and sun. Weekly observations should be recorded.

Construct a "Shadow Stick." Fasten securely a piece of smooth board $4 \times 3 \times \frac{1}{2}$ inches to the end of one $12 \times 3 \times \frac{1}{2}$ inches, forming a right angle. Drive a post in the school yard. Make the top horizontal and on it make a north and south line which will coincide with the meridian of the place. Once a week, at noon, when the sun is on the meridian, place the shadow stick parallel with the line, with the upright piece toward the sun. Mark the shadow cast by a line on one edge of the 12 inch board and record the date. Shadow will increase in length from June 21 to December 21. As the shadow decreases from December 21 to June 21, mark records on the opposite edge. Compare records of March 21 and September 21.

Put a semi-circular piece of cardboard in an east window and one in a west window. Arrange an upright that will cast a shadow. Mark shadow at same time each morning and evening. What relation do the morning shadows, September 21 and March 21, have to the meridian line; the evening?

The length of shadow varies inversely with temperature and length of day. Arc through which the sun passes each day varies directly with length of day and temperature.

Compare force of morning, noon, and evening rays; of June and December rays. Compare climatic and life conditions of Arctic, temperate and tropical areas.

Children should now be able to make very accurate observations and to ascribe reasons for the phenomena observed.

A copy of the United States Weather Bureau should be daily studied. Observations should include:

Sky.

Color—dark, light, and grayish blue.

Twilight.

Cause and period in summer and winter; colors of morning and evening twilight; succession of tints and their cause.

Rainbow.

Situation at different times; tints.

Lunar Rainbows.

Tints.

Sundogs.

Halos.

Solar halo; lunar halo; color of sky within halo.

Precipitation of Vapor of the Air.

Origin of dew; most favorable conditions for formation. More abundant in country or town.

Hoar Frost.

Formation; crystalline structure; where most abundant.

Fog.

Cause; what time of day most common; occurrence on high or low land; near a body of water or land.

LIGHT.

Light plays so important a part in the economy of nature that the children should have some idea of its laws and influences.

1. Sources of Light.

Sun, stars, chemical and mechanical action, electricity, phosphorescence. Compare combustion without light and combustion accompanied with light.

Light by friction; light by percussion.

Indian's manner of making fire—by friction; striking a stone with a piece of steel. Spark in old flint lock guns.

Distinguish between transparent, translucent, and opaque bodies; self-luminous, non-luminous, and illuminated bodies.

Light travels in a straight line through one medium. Distinguish between reflected, refracted, and diffused light. Do we see most things with reflected or diffused light?

In connection with the study of light a sheep's eye or a pig's eye should be dissected, and the internal structure compared with that of the human eye. Carefully remove all flesh and fat. Observe color and texture of coats and optic nerve. With a sharp knife carefully cut through the sclerotic coat, and gently press the contents out on a piece of glass. The watery substance is the aqueous humor, the clear, transparent, firm humor the crystalline lens, and the white jelly-like substance the vitreous humor. The dark circular portion is the iris. Observe the two sets of muscles—radiating and circular.

The Human Eye.

(a) Protections.

Bony socket, cushion of fat, brows, lids, lashes, oil glands at base of lashes, tear gland, tear duct.

(b) Coats.

Sclerotic, choroid, cornea.

(c) Internal structure.

Aqueous humor, iris, crystalline lens, vitreous humor, retina, optic nerve.

Remove the crystalline lens and place it over printed paper. It magnifies the print. Relate this to the construction of lenses.

Uses of Lenses.

(a) Microscopes—simple and compound.

(b) Telescopes—refracting and reflecting.

(c) Cameras.

(d) Spectacles.

(e) Magic lanterns.

(f) Stereopticons.

Hang a prism in the window. Catch refracted light—the spectrum. Much time should be spent in training children to a fine appreciation of color in nature.

Observe clouds at sunrise and sunset; difference between color of summer and winter clouds. Rainbows, sundogs, halos and corona.

Significance of color in flowers, fruit, birds, insects, shells and animals. Contrast the coloring of the spring, summer, autumn, and winter landscapes.

Contrast color of seedlings grown in the dark, shade, and sunlight. Why do house plants turn the upper surfaces of their leaves to the light? Plants assimilate their food under the influence of sunlight. The form of leaves and arrangement on the stem are for the purpose of presenting the greatest leaf area to the light. Observe how the leaves have adapted themselves for this purpose. A field lesson with this point in view is of great profit. Compare plants of the same variety grown in the woods and in the open; leaves of plants that grow on the surface of water with those in the water; the trunks, branches and leaves of trees in dense forests with those in open fields. Compare light demanding trees with shade enduring trees.

Effect of light upon eyes of animals. Compare eyes of mole, cat, dog, owl, and horse.

SOUNDS IN NATURE.

So much of the nature study work is devoted to that which appeals to the child through the eye, that sounds in nature are apt to escape, and the phenomena of sound to be neglected.

Some sounds to be distinguished:

Songs, call notes, alarm calls of different birds.

Notes of different times of day and seasons.

Flapping and fluttering of birds' wings.

Music and musical instruments of insects.

Sound of flight of insects.

Step of a horse—trotter, pacer.

Sounds made by horse, cow, sheep, dog, cat.

Rustle of leaves made by snake, lizard, mouse or bird.

Sound made by wind in leaves of different trees, spring and autumn.

Contrast sounds made by pines, hemlocks, birches, oaks, chestnuts, poplars and Scotch firs; by fields of unripe and ripened corn, wheat, oats and barley.

Sound made by rain on leaves and grass.

Rippling of a stream, dashing of waves.

Detect any musical notes.

I. Classification of Sound.

1. Pleasant—tones—song sparrow's notes.
2. Unpleasant—noise—thunder.

II. Properties of Simple Tones.

1. Pitch—high, cricket's chirp.
2. Intensity—illustration.
3. Duration—illustration.

III. Transmission of Sound.

1. Gases—conductor of sound.

(a) Are sounds clearer on a warm or cold day; summer or winter; colder countries or tropics; mountains or valleys; country or town?

2. Liquids; better conductors than gases.

(a) Strike stones together under water; in air; where is sound more distinct; experience of divers.

3. Solids; better conductors than liquids.

(a) Tap gently on a piece of wood; have another persons ten feet away; listen; tap again, and have the other person put his ear to the wood. In which case is the sound more distinct? Why do Indians put the ear to the ground to discover a footfall? Why is copper used more for telegraph and telephone wires than iron.

IV. Speaking Tubes.

1. Value and Use.
2. Ear Trumpets.
3. Gramophones.

V. Reflection of Sound.

1. Compare Reflection of Sound and Reflection of Light.
2. Echoes: cause.

VI. Velocity of Sound.

1. Light Travels Faster than Sound.

- (a) Lightning and thunder.
- (b) Steam and whistle.
- (c) Flash of a gun and report.
- (d) Falling tree and crash.

EIGHTH GRADE.

THE HOME.

In the A Eighth Grade, the grade below the high school, the children reach the period of sentimentality. The creative energy which has manifested itself in so many ways since the beginning, is now throbbing in their bodies as sex impulses, as natural, as pure, and as right as the beating of their young, vigorous hearts. This force is vital, it is life and should not be crushed, but directed in the proper channels, and avenues opened to them which will afford opportunities for self-expression.

In this grade the central thought is the home. The science work is that which will give them ideas of the best home making and home keeping.

Discuss the location, plans, material, ventilation, heating, lighting, sanitation, decoration, furnishing, books, music, food, dress, care of the house and landscape gardening. Each topic is elaborated and as much of the work is done experimentally as possible. The children should visit the water works, gas works, scientifically constructed buildings to see the lighting, heating and ventilating plants, and machinery for running the elevators; also, the Weather Bureau.

Each pupil can imagine he could build and furnish a house just as he desires. The wisdom of this might be questioned by some. The object is to give the children ideals of the best home possible. The work will certainly give them an impetus toward the best.

It will not be possible to go into the details of the work or describe experiments; it is only hoped that teachers may get suggestions which they can work out individually.

LOCATION.

1. Country.

Advantages.

- Pure air.
- Good food.
- Independent life.
- Contact with nature.
- Low taxes.

Disadvantages.

- Lack of social life.
- Poor communication.
- Bad roads.
- Poor schools.
- No postal service.

2. Suburbs.**Advantages.**

Good air.
 Good schools.
 Good churches.
 Rapid transit.
 Good water supply.
 Fire protection.

Disadvantages.

Distance from business.
 Increased taxes.
 Distance from market.

3. City.**Advantages.**

Library.
 Schools.
 Social life.
 Time saved.
 Rapid transit.

Disadvantages.

High taxes.
 Smoke.
 Danger from fire.
 Crowded conditions.
 Disease.

PLAN.

Number and arrangement of rooms arranged with reference to size of lot, exposure and proximity to other buildings.

Reception hall.	Music room.
Drawing room.	Nursery.
Living room.	Living room.
Library.	Closets.
Dining room.	Attic.
Kitchen.	Piazzas.
Bed rooms.	Conservatory.
Laundry.	Barn.

The children can make their own plans, or copy plans drawn by architects. This is optional. Original plans will show individuality, care and judgment. Good points and bad points in the drawings can be discussed, credit always being given for effort. Each child should keep a book containing the plans and elevations of his house, pictures of interiors—selected from magazines and art and architectural books. Selections give an opportunity for study into character, which is valuable. Selection of furniture is equally interesting—pictures of good sanitary plumbing, convenient equipment for laundry, best designs for cooking stoves, kitchen utensils, furniture for drawing, living and dining rooms, etc.

MATERIAL.**1. Stone.****(a) Kinds.**

Granite.	Limestone.
Sandstone.	Marble.

(b) Characteristics.

Hardness—cutting.

Texture—polish.

Color—beauty.

Durability—economy.

Cost.

Distribution—vertical and horizontal.

Origin—igneous or aqueous.

Quarrying—location.

2. Brick.

Manufacture.

Durability.

Material.

Brick laying.

Kinds and colors.

Advantage of brick.

3. Wood.

(a) Uses.

Floors.

Woodwork.

Furniture.

(b) Kinds.

Oak.

Walnut.

Ash.

Cherry.

Maple.

Birch.

Ebony.

Mahogany.

(c) Characteristics.

Texture.

Markings.

Grain.

Color.

Durability.

Polish.

(d) Cutting.

Straight cut.

Quarter sawed.

VENTILATION.

THE ATMOSPHERE.

1. Composition—mixture.

(a) Nitrogen, four-fifths.

(b) Oxygen, one-fifth.

(c) Carbon dioxide, four-ten thousandths.

(d) Water, variable.

2. Properties.

Invisible.

Has weight.

Colorless.

Presses equally in all directions.

Transparent.

Compressible.

Odorless.

Elastic.

3. Effects of Heat upon Air.

(a) Heat expands air.

- (b) Cold contracts air.
- (c) Location of hot and cold air in room.

4. Experiments.

- (1) Fit a glass tube with a rubber tubing on the end of it into a cork. Fit the cork in a test tube, making it air tight. Place the end of the rubber tubing in a glass of water. Heat the test tube. Why do the bubbles come up through the water?

Heat expands the air. Expanded air presses equally in all directions and finds the easiest egress through the tubes and water.

- (2) Partially fill a small top rubber balloon or bladder with air. Securely tie the opening, making it air tight. Place in a vessel of cold water and heat slowly. When the air has become expanded remove and plunge into cold water.

Account for the result.

- (3) Ascend a step ladder carrying a thermometer. Account for the difference in the reading of the thermometer.

5. Study of Flame.

- (a) Dark zone—no combustion.
- (b) Illuminated zone—partial combustion.
- (c) Mantle—complete combustion.

6. Experiments.

- (1) Place matches successively in the dark zone, illuminated zone, and mantle of a candle. Is there any difference in the time of igniting? Which zone is hottest?
- (2) Place a match or splinter across a flame. Which zone burns the stick most? Which least?
- (3) Press a sheet of white cardboard, held horizontally, upon the flame of a candle, almost down to the wick. Remove carefully. Which zone deposited the most soot? Which least? Why?

7. Experiments with Carbon Dioxide.

- (1) Burn a candle or splinter in a jar of air forming carbon dioxide. Pour lime water into the jar of carbon dioxide and note change in appearance of limewater.
- (2) Breathe through a glass tube into a jar of lime water. Note change in appearance of lime water. Compare results of the two experiments and account for phenomena.
- (3) Place a glass containing lime water on the floor of the school room; on the window sill; near the top of the room; outside of the window exposed to the fresh air. Leave for twenty-four hours. Compare water in the different glasses and give reasons for the change, if there be any. Relate to previous experiments.

8. Respiration.

(a) Organs connected with respiration.

Heart, arteries, capillaries and veins.

(b) Organs used in respiration.

Pharynx, glottis, epiglottis, vocal chords, larynx, trachea, bronchial tubes, air cells and blood vessels.

(c) Chemistry of respiration.

Plants: inspiration carbon dioxide, expiration oxygen.

Animals: inspiration oxygen, expiration carbon dioxide.

Amount of work done by plants.

Amount of work done by animals.

9. Necessity of Air.

(a) Fatal results of poor air; no air.

Asphyxiation.

Drowning.

(b) Necessity of ventilation in—

School rooms.

Churches.

Theaters.

Cars.

Sick rooms.

Hospitals.

Factories.

Mines.

HEATING.

1. Wood.

2. Coal.

(a) Life history of trees and plants.

(b) Food of plants.

Carbon dioxide.

Water.

Nitrogen salts.

(c) Free oxidation of fallen trees and leaves.

(d) Slow oxidation of fallen leaves covered with water.

(e) Subsidence of carboniferous forests.

(f) Deposition of soil.

(g) Transformation of plant material into coal.

(h) Upheaval of submerged area.

(i) Mining of coal.

(j) Use of coal as fuel.

(k) Liberation of the sun's energy as heat.

3. Natural Gas.

(a) Origin.

(b) Source.

- (c) Pumping.
 - (d) Piping.
 - (e) Use.
 - (f) Advantages and disadvantages.
4. Systems of Heating.
- (a) Hot air.
 - (b) Hot water.
 - (c) Electricity.

LIGHTING.

1. Kinds of Lights.
- (a) Pine knots.
 - (b) Oil-fat lamps.
 - (c) Candles, tallow dips and molded.
 - (d) Coal oil lamps.
 - (e) Illuminating gas.
 - (f) Electricity.
2. Advantages and Disadvantages of Each.
- (a) Brilliancy.
 - (b) Steadiness.
 - (c) Economy.
 - (d) Effects upon ventilation and furniture.
3. Location of Lights.
- (a) Ceiling lights.
 - (b) Side lights.

SANITATION.

1. Study of Air.
- (a) Pressure.
 - (b) Compressibility.
 - (c) Elasticity.

Experiments.

- (1) Fill a glass with water; place a blotter securely over the top; turn the glass in every direction. Blotter does not fall from the glass because air presses equally in all directions.
- (2) Partially fill a bottle with water; fit a glass tube of small bore, drawn to a point, through a cork. Place the cork in the opening of the bottle making it air tight and extend the tube under the water. Blow through the tube and observe the bubbles rising through the water. As the water occupies the same space, the air must be compressed.
- (3) Apparatus same as in Ex. (2). After blowing through the tube remove the lips. Water comes from the glass tube in a fine stream. The air being elastic, when it is compressed tries to resume its normal density, presses in all directions,

finds the least resistance in the water and forces it up and out of the tube.

3. Pumps.

- (a) Lifting pumps.
- (b) Force pumps.

Glass models of pumps can be procured at small cost from any supply company, or can be easily constructed by the use of some argand lamp chimneys, corks, wire, and leather valves. The principle of the lifting and force pump is simple, every child can understand it. By observing the experiments on pressure, compressibility and elasticity of air, they will be able to construct pumps and understand their workings. The application is made in wind mills, spraying apparatus, etc.

4. Water Works.

- (a) Drinking.
- (b) Cooking.
- (c) Laundry.
- (d) Sanitary purposes of home.
- (e) Lawns.
- (f) Plants and animals.
- (g) Cleaning streets.
- (h) Sanitary purposes of city.
- (i) Fire protection.

5. Plumbing.

- (a) Sanitary plumbing.
- (b) Dangers of imperfect plumbing.
- (c) Diseases incident to imperfect plumbing.

FURNISHING.

1. Rugs.

- (a) Kind.
- (b) Quality.
- (c) Coloring.
- (d) Manufacture.

2. Furniture.

- (a) Polished wood.
- (b) Brass or iron beds.
- (c) Stuffed furniture—not hygienic.
- (d) Drapery.
 - Light—to admit sun.
 - Material that can be laundered.

3. Coloring of Walls.

- (a) Living and dining room—cheerful.
- (b) Library—quiet, restful color.
- (c) Bedrooms—personal choice.

ART.**1. Pictures.**

- (a) Pictures appropriate for rooms.
- (b) Proper hanging of pictures.
- (c) Correct framing.

2. Statuary.

- (a) Casts.
- (b) Bas-reliefs.

BOOKS.**1. Standard Authors.****2. Selection of Books.****3. Binding.**

- (a) Standard books.
- (b) Current literature.

MUSIC.**1. Instruments.****2. Kinds of Music.****3. Composers.****FOOD.****1. Health.**

- (a) Food produces growth.
- (b) Exercise produces strength.

2. Kinds of Food.

- (a) Animal.
- (b) Vegetable.
- (c) Mixed diet.

3. Hygienic Cooking.**4. Proper Serving of Food.****5. Stimulants.**

- (a) Coffee.
- (b) Tea.
- (c) Alcoholic beverages.
- (d) Evil effects of cigarettes.

DRESS.**1. Economy.**

- (a) Best is cheapest.
- (b) Proper material.
- (c) Artistic coloring.
- (d) Hygienic dressing.

SPRING WORK.

Landscape Gardening.**Suggestions for Planting.**

- (a) Relate plants of a harmonious kind and color.
- (b) Plant beautiful flowers in beautiful groups.
- (c) Contrast methods of growth, and hues of blossom and leaf.
- (d) Make beds growing pictures.

Hints on rural school grounds, by L. H. Bailey. Bulletin 160, Cornell University.

Planting of shrubbery. Bulletin 121, Cornell University.

1. Trees.

- (a) Artistic planting.
- (b) Selection.

Maple,	Elm,
Oak,	Birch,
Ash,	Mountain ash,
Poplar,	Horse-chestnut,
Catalpa,	Evergreens.

2. Shrubs.

- (a) Artistic massing of shrubs.
- (b) Choice varieties.

Snowball,	Spirea,
Lilac,	Barberry,
Syringa,	Japonica,
Hydranga,	Flowering almond.
Roses,	

3. Vines.

- (a) Flowering vines.

Clematis,	Wisteria,
Honeysuckle,	Virginia creeper,
Moonvine,	Morning-glory,
Passion flower,	Sweet peas,

4. Flowers.

Asters,	Petunia,
Ageratum,	Daisies,
Marygold,	Poppies,
Portulaca,	Larkspur,
Zinnias,	Balsam,
Pansies,	Eschlotzia,
Hollyhocks,	Sweet pea,
Bachelor's buttons,	Sunflower,
Candytuft,	Nasturtium,
Phlox,	Mignonette.

5. Bulbous Plants.

Crocus,	Tulip,
Narcissus,	Daffodil,
Hyacinth,	Chinese lily.

6. Propagation.**(a) Separation.**

- (1) Secure a bulb, as tiger lily, Bermuda lily; remove the scales, planting those having bulbules in sand. Note the development of plant and the manner of multiplication. Secure mother bulbs from which young bulbs may be detached.
- (2) Cut a hyacinth bulb into quarters at the base, leaving the upper part intact. Plant in sand and observe the location of the growing bulbules.
- (3) Hollow the base of the hyacinth bulb, plant in sand, observe the development of bulbules.
- (4) Corm. Illustrate by gladiola. Plant in sand, remove from the ground occasionally and observe the development of new corms.

(b) Cuttings.**(1) Stem cuttings.**

Many plants can be propagated by green wood cuttings.

- (a) Soft wood cuttings—geraniums, coleuses, carnations, fuchsias, marguerites, chrysanthemums, roses.

- (b) Ripened green wood cuttings—azaleas, oleanders and roses.

(2) Leaf cuttings.

Begonias and many thick, heavy leaves are propagated in this way.

- (a) Remove the petiole of leaf, and place in moss or sand in moist atmosphere. Small plants will start from the veins.

- (b) Cut the leaf in two pieces and place the cut margin in moist moss or sand in a moist atmosphere.
- (c) Cut the leaf into several fan-shaped pieces; put the strong rib into the moss or sand.

Various Kinds of Separation.

- (a) Tuber separation.
- (b) Root separation.
- (c) Stem separation.
- (d) Leaf separation.

CARE OF THE GARDEN.

1. Preparation of soil.
2. Layout out of beds.
3. Germinating seeds in boxes.
4. Transplanting seed-plants.
5. Care of plants.
6. Gathering harvest.

Pictures for walls of school room, by

Millet, Breton, Rosa Bonheur, Debat, Ponsan, Corot.

Inalterable Carbon Prints, published by

Mason Ad. Braun & Co., of Paris, published by Braun, Clement & Co., Successors, Fine Art Publishers, 249 Fifth avenue, New York.

PICTURES SUGGESTED FOR USE IN SCHOOLS.

ADAM. 1801-1867.

499 Four Kittens.

500 The Cat Family.

JACQUE. 1813-1890.

505 The Sheepfold.

MILLET. 1814-1875.

508 Portrait from Life.

516 Shepherdess Knitting.

509 Angelus.

517 Sheep Shearing.

510 The Sower.

518 Water Carrier.

511 The Gleaners.

519 Woman Churning.

512 Going to Work.

520 Feeding the Hens.

513 Labor.

521 Feeding Her Birds.

514 Potato Planting.

522 The Wood Chopper.

DAUBIGNY. 1817-1878.

530 Landscape. Spring.

ROSA BONHEUR. 1822-1899.

- | | |
|--------------------------------|-----------------------|
| 537 Portrait from Life. | 548 Changing Pasture. |
| 538 Horse Fair. | 553 On the Alert. |
| 539 Coming from the Fair. | 554 A Noble Charger. |
| 540 Ploughing. | 555 A Norman Sire. |
| 541 Lions at Home. | 556 A Humble Servant. |
| 542 An Old Monarch. | 557 Landais Peasants. |
| 543 Morning in the High-lands. | |

AUGUSTE BONHEUR. 1824-1844.

- 561 Goats on the Mountain.

LAMBERT.

- 573 Study of Cats.

BRETON. 1827.

- | | |
|-----------------------|-----------------------------|
| 575 Song of the Lark. | 578 Recall of the Gleaners. |
| 576 Morning. | 579 End of Labor. |
| 577 The Gleaner. | 580 Blessing the Fields. |

LEROLLE.

- | | |
|----------------------|-------------------------------|
| 618 The Shepherdess. | 620 Arrival of the Shepherds. |
| 619 By the River. | |

DUPRE. 1851.

- | | |
|--------------------|---------------------|
| 601 The Haymakers. | 603 Escaped Cow. |
| 602 Milking Time. | 604 On the Prairie. |

LAUGÉE.

- 615 In Autumn

DUTCH ART.**PAUL POTTER.**

- | | |
|-------------|-------------------------|
| 738 Cattle. | 740 Head of Young Bull. |
| 739 Bull. | 741 The Prairie. |

MAUVE.

- 756 Sheep.

GERMAN ART.

MEYER VON BREMEN. 1813-1886.

792 The Pet Bird.

BRITISH ART.

SIR JOSHUA REYNOLDS. 1723-1792.

861 Angel Heads.

862 Age of Innocence.

863 Simplicity.

864 Penelope Boothby.

HERRING. 1795-1865.

886 Pharaoh's Horses.

887 The Village Blacksmith.

888 Three Members of a Temperance Society.

LANDSEER. 1802-1873.

891 The Connoisseurs.

892 Members of the Humane Society.

893 Saved.

894 My Dog.

895 Odin.

896 Dignity and Impudence.

897 Well-Bred Sitters.

898 King Charles Spaniels.

899 Sleeping Bloodhound.

900 Alexander and Diogenes.

901 "There's Life in the Old Dog Yet."

902 Highland Shepherd's Chief Mourner.

903 Piper and Nutcrackers.

904 The Sick Monkey.

905 The Prize Calf.

906 The Font.

907 A Highland Lassie with Fawns.

908 Shoeing the Horse.

909 Wild Cattle of Chillingham.

910 Red Deer of Chillingham.

911 A Deer Family.

912 King of the Forest.

913 Monarch of the Glen.

914 The Challenge.

915 The Combat: Night.

916 The Combat: Morning.

917 Stag at Bay.

918 The Sanctuary.

919 The Deer Pass.

BURNE-JONES. 1833-1898.

946 Spring.

947 Summer.

948 Autumn.

949 Winter.

953 First Day of Creation.

954 Second Day of Creation.

955 Third Day of Creation.

956 Fourth Day of Creation.

957 Fifth Day of Creation.

958 Sixth Day of Creation.

AMERICAN ART.

W. M. HUNT. 1790-1864.

- | | |
|-------------------|---------------------------|
| 1002 Tiger. | 1004 Horses and Cart on a |
| 1003 June Clouds. | Beach. |

UNCLASSIFIED.

- 1093 St. Cecilia. Naujok.

FLEMISH ART.

VAN DYCK. 1599-1641.

- | | |
|----------------------------|--------------------|
| 645 Portrait of Charles I. | 648 Five Children. |
| 646 Children of Charles I. | 649 Baby Stuart. |
| 647 Children of Charles I. | |

ANCIENT SCULPTURE.

- | | |
|----------------------------------|-----------------------------|
| 1160 Apollo. Head. | 1172 Venus de Milo. |
| 1161 Nike Loosening Her Sandals. | 1173 Victory of Samothrace. |
| 1163 Hermes. Bust. | 1174 Victory of Samothrace. |
| 1164 Athena. | 1175 Profile. |

ANIMALS.

- | | |
|--------------------|--------------------------|
| 1301 Camel. | 1308 Asiatic Lion. Head. |
| 1302 Elephant. | 1309 Rhinoceros. |
| 1303 Giraffe. | 1310 Royal Bengal Tiger. |
| 1304 Hippopotamus. | 1311 Shetland Pony. |
| 1305 Jaguar. | 1312 Tigers. |
| 1306 Leopard. | 1313 Zebra. |
| 1307 African Lion. | 1314 Zebu. |

HISTORICAL AND GEOGRAPHICAL.

- | | |
|-----------------------------------|-------------------|
| 1401 Yosemite; from Artist Point. | 1404 Pike's Peak. |
|-----------------------------------|-------------------|

EGYPT.

- | | |
|---------------------------------------|---|
| 1451 Colonnade in Great Hall. Abydos. | 1459 Karnak. Entrance to Temple of the Rameses. |
| 1455 Ghizeh. Sphinx and Pyramids. | |

ENGLAND.

- | | |
|----------------------------|-------------------------|
| 1481 Houses of Parliament. | 1485 Westminster Abbey. |
| 1482 St. Paul's Cathedral. | |

FRANCE.

- | | |
|------------------|----------------|
| 1537 Madeleine. | 1550 Pantheon. |
| 1545 Notre Dame. | |

GERMANY.

- 1601 Cologne Cathedral.

GREECE.

- | | |
|-------------------------|-----------------|
| 1611 Temple of Minerva. | 1616 Parthenon. |
|-------------------------|-----------------|

NORWAY.

- | | |
|--------------------|------------------|
| 1644 Midnight Sun. | 1649 North Cape. |
|--------------------|------------------|

SPAIN—GRENADA.

- 1850 Alhambra.

SWITZERLAND.

- | | |
|------------------|--------------------|
| 1883 Mont Blanc. | 1884 Mer de Glace. |
|------------------|--------------------|

ITALY—FLORENCE.

- 1662 Baptistery.

MILAN.

- 1685 Cathedral.

PISA.

- | | |
|---------------------|------------------|
| 1718 Leaning Tower. | 1720 Baptistery. |
|---------------------|------------------|

ROME.

- | | |
|---|-----------------|
| 1750 St. Peter's. | 1763 Colosseum. |
| 1758 Bridge and Castle of St.
Angelo, with St.
Peter's. | 1766 Forum. |

VENICE.

- | | |
|---------------------|-------------------|
| 1802 St. Mark's. | 1822 Eve. Statue. |
| 1821. Adam. Statue. | |

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Also, pictures in colors—birds, animals, minerals, fruits—and pictures of forest trees—the tree, a section of the trunk, a spray of leaves, and a short description of the tree—may be obtained of the same firm.

STATUARY.**PARIS.**

la Venus de Milo (ant.) Louvre.

ROME.

47a Jupiter (bust) Vatican.

55a Belvedere Mercury, Vatican.

RAPHAEL'S DAYS, Farnese Palace, Rome.

290b Diana (Monday).

291b Mars (Tuesday).

292b Mercury (Wednesday).

293b Jove (Thursday).

294b Venus (Friday).

295b Saturn (Saturday).

296b Apollo (Sunday).

RAPHAEL'S HOURS.

297b First Hour of the Day.

298b Second Hour of the Day.

299b Third Hour of the Day.

300b Fourth Hour of the Day.

301b Fifth Hour of the Day.

302b Sixth Hour of the Day.

303b First Hour of the Night.

304b Second Hour of the Night.

305b Third Hour of the Night.

306b Fourth Hour of the Night.

307b Fifth Hour of the Night.

308b Sixth Hour of the Night.

FRENCH SCHOOL.**COROT, JEAN BAPTISTE CAMILLE (1796-1875).**

572b Landscape. Louvre, Paris.

573b Landscape, Morning. Louvre, Paris.

574b Landscape. Durand, Ruel Collection.

575b Orpheus and Euridice.

576b Diana at the Bath.

577b Landscape.

578b Landscape.

MILLET, JEAN FRANCOIS (1814-1875).

580b First Step.

581b Feeding the Nestlings.

582b The Gardener.

583b The First Step.

584b The Sower.

585b The Gleaners. Louvre, Paris.

586b The Spinner.

587b The Basket-maker (drawing).

These selections are from the catalogue of Francis Hendricks & Co., Art Publishers, Syracuse, N. Y.

APPARATUS.

1 beaker, 100 c. c.	1 mortar and pestle, 85 mm.
1 beaker, 200 c. c.	1 porcelain crucible and cover.
1 box matches.	25 round filters.
1 clay pipe.	1 sand bath, flat.
1 cork for cylinders.	1 sand bath, hemispherical.
3 cylinders.	1 stick charcoal.
1 deflagrating spoon and guard.	6 test tubes, 5-inch.
1 evaporating dish, No. 00.	1 test tube holder.
1 flask, 100 c. c.	1 test tube rack.
1 flask, 250 c. c.	1 triangular file.
1 funnel, 65 mm.	1 tubulated retort.
2 funnel tubes.	1 U-tube, 4-inch.
1 glass bottle.	1 watch glass.
3 glass plates.	1 wire gauze, 4x4 inch.
$\frac{1}{2}$ length glass rod.	1 galvanized iron pan, 15x18x3.
2 lengths glass tubing.	Glass tubing of large and small
$\frac{1}{2}$ dozen quart fruit jars.	bore.
$\frac{1}{2}$ dozen panes of window glass,	1 yard of rubber tubing.
12x15.	1 alcohol lamp.
$\frac{1}{2}$ dozen argand lamp chimneys.	Corks.
$\frac{1}{2}$ dozen tumblers.	Horse shoe and bar magnets.
1 dozen test tubes.	Iron filings.
Hydrochloric acid.	Copper beaker.
Sulphuric acid.	Zinc.
Copper sulphate.	Thermometers.
$\frac{1}{2}$ length hard glass tubing.	

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AN ACT

Authorizing levy of tax for establishing libraries.

Section 1. Be it enacted, etc., That for the purpose of securing a system of free, non-sectarian, public libraries on a substantial and permanent basis throughout the Commonwealth, authority is hereby given to the board of school directors, or to any board or organization having control of the common schools, in each and every common school district, except in cities of the first and second class, whenever the same may be decided upon by a majority vote of all the members thereof, to provide a place for and establish and maintain such public library for the general use of the residents in the district, subject to the ensuing provisions of this act.

Section 2. Said board may set aside the whole or a portion of any school house, now or hereafter erected, within the district for the uses and purposes of such library, having due regard to the convenience of the citizens, and may make any changes, repairs or additions that may be necessary to properly carry out the objects of this act, or, at its option, may lease, purchase or erect a suitable building in

some convenient location for the use, storage and accommodation of such library, but no land or structure shall be purchased or building commenced until the cost thereof has been fully provided for under the laws regulating the erection of new school houses within the district.

Section 3. It shall be lawful for said board to levy a tax for the purchase, improvement and maintenance of said library not exceeding one mill in any one year on the valuation of the property assessed for school purposes in the district, which tax shall be collectible as the school taxes of the district are at the time of collecting the same.

Section 4. The public library of each district shall be under the general management of nine trustees acting as the agents and appointees of the school board, who shall approve all plans for its storage and accommodation, purchase and take charge of all books, maps, documents, relics and literary, historical or other contributions, appoint all employes and make all regulations and do all things necessary to its government, preservation and maintenance, subject to the approval of the board. The president and treasurer of the board and the superintendent of the schools of the district (or if there is no such officer the secretary of the board) shall be ex-officio members of the board of trustees. The other six members shall be elected by the school board, two each for one, two and three years, and annually thereafter two members shall be chosen by said board for the term of three years. Each trustee shall serve until his successor is elected, and in case of a vacancy it shall be filled by the school board for the unexpired term. The trustees shall make a report to the school board once each year, and oftener if called upon, of such subjects and in such manner as may be required by said board.

Section 5. All public libraries established as above shall be under the general supervision and subject to the inspection of the State Librarian, who is hereby empowered to require thereof to be made by the trustees at such time and in such manner as he may see proper.

Section 6. It shall be lawful for the school board of any common school district, and their successors in office, to receive and hold, free from all collateral inheritance tax, any devise, bequest, grant, endowment, gift, donation or contribution of property real, personal or mixed which shall be made for the establishment, improvement or maintenance of a public library as herein provided for, and the same to apply to the purpose for which made or given, and said board, or their successors in office, are hereby authorized to bring suit and do all necessary acts for the recovery, holding, use and application thereof: Provided, That this act shall not apply to cities of the first class: Provided further, That in cities which have established a board of trustees for the management of a free library established by said municipality, any land or buildings appropriated to free library pur-

poses under the operation of this bill, shall be under the control of said board of trustees.

Section 7. All laws or parts of laws inconsistent herewith are repealed.

Approved—The 28th day of June, A. D. 1895.

DANIEL H. HASTINGS.

No. 9.

A SUPPLEMENT.

Section 1. Be it enacted, etc., That in any school district, except cities of the first and second class, wherein there is or shall hereafter be established, otherwise than under the provisions of the act to which this is a supplement, a free non-sectarian public library, the school directors, board of organization having control of the common schools of said district may, instead of establishing another public library and providing for its government, extend aid to such library on such terms as to control and management as shall be agreed upon between the managers thereof and the school authorities, and for that purpose may levy taxes provided for in the act to which this is a supplement in the manner provided therein.

Section 2. The managers of any public library receiving aid under this act shall annually report to the school board furnishing such aid an account of the expenditure of the money so received, under the oath of the managers or their secretary and treasurer, and such account shall be subject to the jurisdiction of the auditors by whom the accounts of the school board are audited in like manner as their accounts.

Approved—The 30th day of March, A. D. 1897.

DANIEL H. HASTINGS.

THE CONSOLIDATION OF COUNTRY SCHOOLS AND THE TRANSPORTATION OF THE SCHOLARS BY USE OF VANS.

BY H. H. LONGSDORF, A. M., M. D., *Dickinson, Penna.*

THE CONSOLIDATION OF SCHOOLS IN THE RURAL DIS- TRICTS OF PENNSYLVANIA.

Before entering upon the discussion of consolidation as a measure for the advancement of the schools in the rural districts of this State, it may be wise to glance at some of the underlying and dependent questions connected with it.

The country school problem is not wholly an educational problem in the sense in which the term is ordinarily used. It comprises many subjects besides the quality of text-books or teachers—of method and salary, and other vital matters. It is not—putting it on a wider basis—a question of expediency, utility or of individual preference or convenience, though these enter into it. It is in fact a many-sided problem, including factors of wide-reaching value, and containing many unknown quantities relating to sociologic and economic science.

Thus, from the very outset, we have a divergence from the ordinary aspect of school questions. In the city, there is a fixity of conditions which reflects itself in the well-equipped school and the independent methods by which it is conducted. The aggregation of wealth and population, give rise to certain standards and authorities, official and non-official, which give, to an extent, security and stability to the social structure of which the school is a part.

Formerly, a somewhat similar state of things prevailed in the country. The rural population was stable and prosperous, and any matter of public interest was more or less a common charge.

MUTUAL INTEREST OF CITY AND COUNTRY.

Whatever may be said of the advantages or disadvantages of the city or of the country upon the life and development of the



School Vans with School Children, Gustavus Township Consolidated School, Gustavus, Ohio.

individual, or upon the prosperity of the State, it is certain that the welfare of the one is bound up in that of the other. The market cannot exist without the producer; the producer cannot exist without the market. The machinery is supplied by the city; the raw material by the country.

It follows that in the educational life of these two allies, no discrimination of privilege should be shown. Their interests being mutual, their duties should be reciprocal, and the State should have a care that her bounties are adjusted to the necessities of the weaker rather than of the stronger of the two.

As well might we expect to see the stately river bearing upon its bosom the evidence of prosperity and wealth, if the source in the far-away hills or rocky cliffs were dried up, as to look for the marks of a high civilization in city or town where the just needs of the country are disregarded. On the contrary, deepen and widen the spring, remove obstructing influences, shade it from the withering glare of the sun, help Mother Nature to induct into the tiny channel other contributory streams now choked by neglect, and it will become from source to outlet a beneficent influence. Along its widening course "waste places will be made glad," homes will be reared, industry will find its reward, human aspirations will have their fruition, and these, in turn, will react on the greater centres of population and wealth, where competition and the enervating effects of want on the one hand and luxury on the other have deadened the conscience and lowered humanity's ideals.

Pennsylvania, with her long list of rapid growing cities, her enormous and fast increasing manufacturing and commercial interests, cannot afford to overlook her obligations to the humblest citizen within her borders, either for self-preservation or upon the principle of equity and justice. Every citizen, however obscure or ignorant, is a factor for or against the public weal, and it is, therefore, the plain duty of the State to place within his reach the best means of making him a thoughtful and intelligent member of the body politic. It is a measure of self-preservation, because the class so reached are the natural friends of the theories that tend to desolate society or to increase the ranks of the criminal and the pauper. It is just, because it extends a helping hand to the poor man who otherwise would be doomed to a vain struggle with evil fortune.

It is highly desirable that the country school should be able to impress upon its outflow, character and intelligence. If properly administered, it would form a counteracting agency in the vast and significant movement of the strength, ambition and creative energy of the country to the city. Thus, the permanence and true value of our institutions will depend, in great measure, on the quality

of the human product now represented in the schools of the rural districts. For it is true as when the line was first penned that:

"Man is the nobler growth our realms supply."

CHANGES IN THE RURAL LIFE OF PENNSYLVANIA.

The changes consequent upon the rapid growth of the nation as a whole, have not left undisturbed the landmarks set by the early settlers of Pennsylvania. New conditions have arisen, new outlooks opened; the very thought of former times has changed; whereas the farmer of twenty-five or forty years ago regarded himself as almost a part of the agricultural interest of the State, with his ambition bounded by the desire for acquiring land and farm improvements, he now scarcely thinks it desirable, even if it were possible, in many cases, sharing and sympathizing with the discontent that possesses the younger members of his household.

Around the farm, as it then existed, clustered many minor interests. Mechanics, who before the advent of machinery, found a livelihood in making and repairing farm implements; laborers who helped to till the soil—local industries that drew vitality from the generous surroundings and sometimes amassed modest fortunes—various branches of domestic service; these, with others, felt the impulse that came from the prosperous farm.

The farmer and the class identified with him understood the worth of an education, a fact better attested by the long lists of eminent and successful men reared in the country of that period, who are now occupying positions of prominence in every department where learning and mental sagacity count. The school was well cared for and its advantages prized. The sturdy country boy and girl "meant business" when they entered the school room in the fall. They knew their time for education was limited and, as a rule, made the most of it, and studied and *thought* with a force and originality of method that easily broke down many of the obstacles that doubtless existed. The age of the pupils was greater and they brought a maturity of thought to their work which, under less stimulative conditions, does not now exist. With this, there was the daily training in application and persistence nowhere so well impressed as on a well-managed farm or busy workshop.

The changes that have been wrought in the aspect of the rural community have come from causes outside of the sphere of farm industries. The lowered price of land and farm products accounts for them in part. Others bearing upon it, are the natural development of the country at large, through increase of population by foreign immigration and settlement of the vast areas of the west, otherwise increase of occupations for females, liberation of slave labor.

Chief among the causes for the abstraction of the more ambitious element among the youth of the rural districts is the differentiation of occupation which is constantly being intensified. Out of this has grown a demand for specialized knowledge and skilled labor in every department of productive energy, whether of physical or intellectual output, a demand that must be met by educational devices adapted to it.

A more satisfactory and accurate idea of the changes that have affected the rural population of Pennsylvania and some other agricultural States in the last several decades, can be obtained by a brief survey of the census returns relating to occupation.—(From Bulletin No. 11, U. S. Dept. of Labor.)

**PERSONS ENGAGED IN GAINFUL OCCUPATIONS BY SELECTED CLASSES,
1820.**

Classes of Occupations.	Persons.
Agriculture,	2,070,646
Commerce,	72,493
Manufactures,	349,506
Total,	2,492,645

The total in the above table must not be taken as representing all the persons engaged in remunerative labor, the inquiry being limited to the number engaged in these three classes.

In the census of 1840, the enumeration was more specific, resulting as follows:

**PERSONS ENGAGED IN GAINFUL OCCUPATIONS BY SELECTED
CLASSES, 1840.**

Classes of Occupations.	Persons.
Mining,	15,210
Agriculture,	3,719,951
Commerce,	117,607
Manufactures and trades,	791,739
Navigation of the ocean,	56,021
Navigation of canals, lakes and rivers,	33,076
Learned professions and engineers,	66,255
Total,	4,798,969

The total of the seven classes here represented, does not include servants and the large number of persons engaged in other do-

mestic and personal services, governmental officials, clerks and employes. In 1850, the inquiry was limited to free males over fifteen years of age, and the printed results comprehended simply a list of 323 occupation designations, not classified according to number engaged in each. In 1860, the specific occupations were given in the census report for all free persons over fifteen years of age, without distinction as to sex. The list comprised 584 items. In 1870, occupations were classified under four general heads, namely, agriculture, professional and personal services, trade and transportation, and manufactures and mechanical and mining industries, comprising 338 occupation designations. This presentation of occupation comprehended all persons ten years of age or over, sub-divided according to sex, their age-periods and, for those of foreign birth, according to twelve principal nationalities.

In 1890, the same general plan of classifying occupations was observed as in 1870 and 1880, but the sub-division according to sex, age-periods and nationalities of the foreign element was in 1890, very much extended and many other important details added.

NUMBER AND PER CENT. OF PERSONS TEN YEARS OF AGE OR OVER IN EACH CLASS OF OCCUPATIONS, BY SEX, 1870, 1880, AND 1890.

Census Years and Classes of Occupation.	Number.			Per Cent		
	Males.	Females.	Total.	Males.	Females.	Total.
1870.						
Agriculture, fisheries and mining,	5,744,814	297,049	6,141,863	53.84	21.62	49.11
Professional service,	278,841	92,257	371,098	2.61	5.02	2.97
Domestic and personal service,	1,338,663	972,157	2,311,820	12.55	58.00	15.48
Trade and transportation,	1,209,571	19,628	1,229,199	11.34	1.08	9.83
Manufacturing and mechanical industries,	2,098,246	353,997	2,452,243	19.66	19.23	19.61
Total,	10,669,635	1,836,288	12,506,923	100.00	100.00	100.00
1880.						
Agriculture, fisheries and mining,	7,409,970	594,651	8,004,624	50.25	22.46	46.08
Professional service,	425,947	177,255	603,202	2.89	6.70	3.47
Domestic and personal service,	2,821,937	1,181,506	3,508,443	15.75	44.63	20.14
Trade and transportation,	1,803,629	62,852	1,866,481	12.23	2.96	10.73
Manufacturing and mechanical industries,	2,783,459	630,890	3,414,349	18.88	23.33	19.63
Total,	14,744,942	2,647,157	17,392,099	100.00	100.00	100.00
1890.						
Agriculture, fisheries and mining,	8,333,512	679,522	9,013,236	44.28	17.36	29.65
Professional service,	632,646	311,637	944,283	3.36	7.96	4.15
Domestic and personal service,	2,692,879	1,667,698	4,360,577	14.31	42.60	19.12
Trade and transportation,	3,097,701	228,421	3,326,122	16.46	5.84	14.63
Manufacturing and mechanical industries,	4,064,051	1,027,242	5,091,293	21.59	26.24	22.39
Total,	18,821,090	3,914,571	22,735,661	100.00	100.00	100.00

According to the above figures, persons engaged in agriculture and mining, constituted very nearly one-half (49.11 per cent.) of the whole number of persons occupied in 1870, and less than two-fifths (39.65 per cent.) in 1890. More than two-thirds of this loss has occurred between 1880 and 1890. There has been, on the other hand, an increase in the proportion of persons engaged in each of the other great classes in 1890 as compared with 1870, the largest increases being shown for persons engaged in trade and transportation and in manufacturing and mechanical industries. In 1870, persons engaged in agriculture, fisheries and mining constituted 15.93 per cent. of the total population, and but 14.39 per cent. in 1890. The percentages of persons engaged in agriculture only, were 15.43 in 1870, and 13.68 in 1890. These figures show a steady decline in the proportion of persons engaged in agricultural pursuits, and the relatively decreasing importance of agriculture as a means of livelihood.

If the census tables of the last three periods could be further quoted, taking the States and Territories individually, a still more definite idea could be obtained as to the increase of manufacturing and mechanical pursuits and the decline of agricultural occupations in the North Atlantic States. In 1890, only a little more than 6 per cent. of the total population in Pennsylvania was engaged in agricultural pursuits.

Further analysis of the tables of the last two periods shows a relatively larger increase of female workers over male workers. Division of classes of workers into groups show a rise in occupation in Pennsylvania. A considerable increase of women in professional service and in manufacturing and mechanical industries has occurred, reaching nearly 7 per cent. in 1890.

It must be remembered that the above quotations are of the simplest form. They are given as indicative of the trend of occupations and the increase of wage-earners.

Deductions from this partial presentation of industrial progress in recent years are:

1. The scale of labor has risen, there being a perceptible increase in the proportion of persons engaged in the higher grades of work in 1890 as compared with conditions twenty years earlier.
2. The population in the rural districts is in a transitional state, part of it moving toward the centralized industries in the cities and manufacturing centres. It is there dispersed according to ability, knowledge and taste. Another part remains amid the less affluent and alluring surroundings, to utilize the agricultural possibilities in the most economical and practical way, keeping up, to some extent, the old-time traditions, beautifying the country, opening up new avenues of industry and cultivating in patience and hope the growth

of future expectation, thus serving as a counterpoise to the tendency to desert the country.

3. *The city-ward tendency is not a temporary movement.* It is steadily increasing and will go on *if some preventive remedy is not applied*, until deterioration not only of material interests, but of the race sets in. Poverty, illiteracy and a host of evils that accompanies the loss of motive to high living, will follow in the train of neglected rural interests. Examples are not wanting of these effects.

The mountain whites of the South afford an illustration of the results of such a tendency operating through several generations. The original stock from which they came was good, but living remote from civilization and out of the current of modern progress, they have lapsed back into a condition of semi-barbarism. What their influence is as against order and governmental safeguards, the events in Tennessee and Kentucky within the last year or two go to show. Other instances of a like nature abound in the detached communities of the older and newer States. Pennsylvania, in the ten years between 1880 and 1890, shows a loss of population in 919 townships. No accurate estimate of the loss up to the date of the twelfth census can be given, but from the growth of the cities in that period and the decline of the smaller industries of the rural districts, a fairly just opinion can be formed that the adverse influence upon the country has not diminished.

The most powerful factor in opposing the tendency to the cities is education. From the educational side must come a counter movement, strong enough to offset in some degree the discontent of the farmer and the necessities of the laboring class. Along with these must be met a class of interests not properly of a material sort. The desire for a higher education and for opportunities leading into the wide field of asthetic and artistic employment and of the gratification of strong individual tastes, has grown until it has created a demand for specific elementary training, in the common school, as insistently urgent as the knowledge of the three R's.

THE COUNTRY SCHOOL AS IT EXISTS DOES NOT ANSWER THESE SEVERAL WANTS.

We have traced the steady increase of influence adverse to the rural population. We have seen that they are continuing in an ever-progressing ratio. The Pennsylvania of to-day is not what it was in the era when the "Great Commoner" championed the common school system so intimately linked with his name, The system which has been found so well adapted to the conditions of the past has been outgrown and no longer in harmony with the spirit of the age, be-

cause elastic as it is, it does not furnish "equal opportunities and enlightenment for all." Our practical forefathers devised the school machinery so that it might reach to the smallest and remotest nook where a ward of the State could take up its abode. The corner stone of the structure they built up in the hope of securing the widest liberty of thought and action for the people they sought to serve, was "equal rights to all." It may be said, the system as founded still stands, but if it no longer subserves its original purpose, *we and not they must be held responsible.*

The consolidation of the schools in the rural districts is a practical and feasible measure. Premising that consolidation cannot as yet be made universal in application in this State, it is offered as a remedy for existent ills in the districts most affected by the disintegrating processes of later periods, subject to many modifications of place and circumstance.

Let us examine in brief detail some of the phases of educational life where it would apply, and some of the benefits accruing from its adoption.

THE SMALL SCHOOL.

A practical educator—and as wise as practical—has said: "The first thing a good school wants is children." A very small school is almost always a poor school. There is absent in it the incitement of rivalry and friendly emulation as well as the encouragement found in companionship. If each child pursues a different study, as sometimes happens, there is still less of that reflex action which lightens the task and opens the mind. The difficulty of organization in a small school is so great as to be practically impossible. In the country, bad roads, distance, stress of weather and, in frequent cases, disinclination, serve to keep the school even smaller than the number of children of school age would warrant. In a school of this kind there is frequently great irregularity of attendance and unpunctuality in lessons, failures which may be forgiven under the circumstances. There is no spring of enthusiasm to inspire the teacher or of sympathy or interest on the part of the patrons. Nothing can be done in a school of small size in the way of special studies, unless the teacher is phenomenally conscientious and possesses strong personal qualities.

Individual teaching often brings good results. It was the method most in vogue in the southern States in the ante-slavery period and many accomplished scholars came from the training of the governess or private tutor who was brought there from the best northern schools. But this was a wholly different system. As the ordinary common school of low grade is found in the sparsely settled districts, it possesses little educative value, and might with advantage be closed and its feeble force united with a larger one.

THE LACK OF TRAINED TEACHERS IN THE COUNTRY.

Every year brings an output of trained and presumably efficient teachers from the normal schools and colleges. They are full of enthusiasm and real love for their work. From contact with disinterested and unselfish minds and from purposeful books they have imbibed a certain nobility of purpose; something of the passionate fire of humanity animates them. They long for opportunity to impart something of the spirit that burns in their hearts. But they also possess a share of self-appreciation. They are conscious of power in the direction of their elected work and they decline, except under the compulsion of circumstances, to "bury themselves in the country." They have a natural ambition. The little school, with nothing in its exterior surroundings or inside equipment to attract the eye or inspire the mind, is too insignificant for a teacher who hopes to demonstrate the dignity of his profession. The cultivated taste that found food and fostering desire in the hall of learning left behind, with its specific influences of intellectual riches, cannot at once contracted to the narrow limits enclosed by the rustic fence, or not enclosed at all, overgrown with weeds, destitute of even the elements of the picturesque.

The ordinary graduate-teacher is not a missionary. He cannot justly be blamed if he turns to the city or prosperous towns and takes a place in the better organized and better protected school. But sometimes such a teacher gets the country school. Influences of local relationship, or other affiliations with the community, or necessity or desire for experience often lead to such a result, and "just for the term," "till something better turns up," the place is filled, sometimes satisfactorily filled, but often quite the reverse. It cannot be expected that a teacher who is ever on the alert for bettering his position, who is perhaps pursuing an upward course of study himself, will do more in such a school than the letter of the law demands. There is a pathos in the situation, not sentimental, but real pathos. The school is taught; it may be the last opportunity for some gifted child—and if it fails—if the school is ill-taught, the evil, the far off interest of misjudged action may change the destiny of a human soul.

Here, then, are two factors common enough—every country director knows—the small school, the trained but dissatisfied teacher. The unsightly building, the antiquated and insufficient supplies, the cultivated but unsympathetic leader. If two or three or ten such schools, varying a little as to quality and numbers, but all on the same plane could be united, if the saving of salaries and fuel and repairs could be expended on better equipment and better house improvements, if a sufficient teaching force could be supplied in the elementary and special departments, the dissatisfied teacher—dissatisfied because hopeless of achieving good results, would very likely

blossom out into a brilliant potentiality, or if not he could be supplanted by one of finer fibre.

It is possible to keep up a school of five, or eight or ten pupils. It is done every year in Pennsylvania. So long as the State continues to make such noble provision for the educational needs of her children, and so long as the taxpayers are satisfied, it can be done. So long as this is the only available way of reaching the children of any district and supplying them with such instruction as can be given under the circumstances, it *must* be done. It is not claimed that such schools do not accomplish a certain amount of good. Probably in some of these schools there will be one or more examples of that true American grit which achieves its object in spite of difficulties, and so serve in coming generations "to point a moral or adorn a tale," for the encouragement of the poor boy in the country, who like Lincoln and Grant "grows to fame's high towers" in the face of hindering obstacles. It was Huxley who said, "it was worth a million dollars to discover a Faraday." No era has a monopoly of human genius, and if Pennsylvania were to expend wisely a million dollars on the schools of the enfeebled rural districts, another, and more than one as great as Faraday might arise out of obscurity and the mists of ignorance and go to his predestined work.

CONSOLIDATION AN AID TO ADVANCEMENT THROUGH CLASSIFICATION.

One of the greatest objections to the mixed country school is the impossibility of profitably classifying the pupils. For this purpose the large schools in the more populous districts or suburban villages are even more unwieldy than the very small one. It is accomplished, and very fairly, considering the difficulties, but it is at the expense of a vast deal of energy and brain work that might better be applied in more direct teaching. The classification established at the beginning of the term is liable to be broken in upon by the late entering pupils who have been employed during the summer and early fall. The teacher is thus often forced to form new and additional classes, and valuable time is taken from those already at work. The great desideration in schools where the course of study is confined to the elementary branches is a reduction of class exercises. Where there is no apparent limit to the spelling and reading and rudimentary arithmetic classes, such as are found in every country school, there is no mental stimulus for teacher or pupils, and teaching and learning alike become a joyless drudgery.

But as soon as the school is grouped in partial grades the trouble diminishes. The promotion from class to class and from grade to grade affords a wholesome incentive to the child, and to the teacher

a better opportunity of impressing the true principle of education upon the school. If two or any number of such schools near enough to each other to make it convenient were united, a more complete system of classification would follow, and there would be at once the nucleus of a high school. Enough of the more advanced pupils would be found able to take one or more of the higher branches, the loiterers would feel the impulse of the grading, and the gain throughout would be so great as to speedily yield a percentage of high school and preparatory normal school students who otherwise would in all probability drop out of school while still in the elementary course. The gain in time for the pupil would be enormous; practice in drawing, reading from selected literature, instruction in Nature studies, physical culture and other special training could be substituted for the old methods.

CONSOLIDATION THE ONLY METHOD BY WHICH EVERY TOWNSHIP IN
THE RURAL DISTRICTS CAN HAVE A HIGH SCHOOL.

From the preceding propositions, it will be seen that without a definite change of system, the pupils of the outlying schools cannot go much beyond the elementary branches. The lack of appliances for illustrating the principles of the higher mathematics and other sciences, want of time from the necessity of maintaining numerous classes, and the absence of systematic grading, are reasons for the school, even under a good teacher, never getting farther than a certain point—a point a little below the grammar school grade in better schools. By that time the weeding out process has begun. The boys usually drop out, first, either aiming at securing employment or obtaining better educational advantages elsewhere. The girls remain a little longer, but none, or very few, stay until they have thoroughly mastered the few advanced studies possible to be taken in such mixed schools. The consequence is that even under the provision by which properly fitted pupils can be admitted to contiguous schools of a higher grade, they cannot claim it.

The high school contemplated under the consolidated system is, however, something different from the ordinary town or city high school. It is designed to be a *training school* with a specific object; namely, that of fitting a class for its sure duties, to put the worker in harmony with his work.

One of the anomalies of the education thought of the day, is to apply the same general principles to the education of the country child as to that of the city; yet their environments are antipodal. A hoped-for result of consolidation is to correct this and to give a practical trend to the first steps in learning.

In this, as in other things, the city takes care of itself. The school early gives a bias to the child's outlook in life. It is taught its duties to the public, to society, to all that relates to civic responsibilities. It early recognizes the importance of conforming to conventional rules and customs, and to the power of public opinion. It develops an interest in local matters, and takes a pride in local progressive movements.

External influences are brought to bear upon its education. The press, the pulpit, the social reformer, unite in holding up high ideals of thought and living before the schools. Libraries and reading-rooms give information as to the world without, and the place it holds for the youthful aspirant, so that by these influences, with the special knowledge gained in passing upward, the student is enabled to judge of his own fitness for a selected course in life.

The country school has the same curriculum, without the practical illustration, the proposition without the demonstration. The outcome of the child's education is left largely to chance and circumstances, and of the class that goes forward into higher courses of learning, a large proportion enter the learned professions, which severs the tie that would naturally hold them to home and childhood associations. It is a significant fact that instances are rare where the great man in letters or science who sprung from the country, returns to lay the tribute of affection at Nature's feet. With a few noble exceptions, he is content to let the farm that nourished his youthful strength go to ruin and decay, while he builds libraries and endows schools of learning in the city that shares his fame. With a sentimental regret he can gaze upon the poorly appointed school house, while he showers benefits upon his *alma mater*.

In this connection, it may be noted as a singular fact bearing upon the subject, that of the thirty or more colleges and universities in Pennsylvania, there is only one entirely devoted to the promotion of agricultural interests. It is probable, if the country high school, as proposed, could be established, with special courses leading to expert knowledge in various farming and dairy departments, a large increase of students desiring to enter upon these higher courses of study would ensue.

SELECTED COURSES IN EDUCATION FOR COUNTRY STUDENTS.

If the children of a district were brought together and placed under a competent head, and the school in good working order, it would then be possible to give some order to the division of studies for those in the higher grades. For such as intend going into the mechanical arts, a saving of time could be thus effected. For those looking forward to a classical or literary course leading to the professions and for those who expect to remain in the country and be-

come identified with its local interests, either in farming, mining, fruit culture, or any of the industries established in different parts of the State, congenial and profitable instruction could be provided, such as would at once strengthen the intellect and enable them to take advanced ground in their further progress.

Statistics are not obtainable to show what proportion of the students in the leading institutions of this State came from the country, or the whole number pursuing the more professional and technical courses of study during four years preceding graduation. It will be seen, however, from the lists of graduates, that Pennsylvania favors practical and speedy results in learning as well as in more material matters. There is not so much stress laid upon knowledge for knowledge sake as in New England and some other States

The University of Pennsylvania, of degrees conferred June, 1900, there were:

A. B.,	16
Music,	2
B. Sc.,	27
B. S. Biolog.,	5
M. A.,	11
Ph. D.,	15
Honorary,	2
Total,	78
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B. Sc. architecture,	7
B. Sc. chemistry,	11
B. Sc. civil engineering,	4
B. Sc. economics,	10
B. Sc. electrical engineering,	7
B. Sc. mechanical engineering,	7
M. S. technical,	1
Mechanical engineering,	1
Total,	53
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Law,	83
Medicine,	180
Dentistry,	144
Veterinary,	11
	<hr/>
	318
	<hr/>
	471
	<hr/>

In all, there were 549 degrees conferred, of which 15 per cent. represent literary training and 85 technical and trade pursuits.

Taking three other institutions:

	Literary degrees.	Technical or trade.
Lehigh,	11	48
Lafayette,	20	34
Pennsylvania State,	4	42
Total,	45	104

Viewed from the standpoint of the country or State at large, it would be a gain to prepare the students taking these courses in the home high school, the terms of admission being made on the high school standard. More students would enter the higher institutions and all branches of industry would ultimately be benefited.

The possibility of taking such a higher course would act as a stimulus to the country student, keeping him out of the way of the commoner allurements of the city. Thus, briefly stated, the consolidated high school might be expected to bring about these results:

1. A gain in time.
2. A gain in number of students.
3. A reduction in expense of higher education.
4. A reduction of the number going into the laboring employments.
5. A gain to the individual and to the State, reacting favorable on each.

A COURSE OF STUDY ADAPTED TO THE CONSOLIDATED COUNTRY SCHOOL.

As has been seen, it is not desirable to make the country school a reflected copy of the city school, however excellent the latter may be. The departure from the course usually laid down, should begin in the elementary grades. Every encouragement and incitement should be offered to secure a thorough and practical knowledge of trees and plants, insects and animals, rocks, and, more than any of these, of soils.

Comparisons of scenery and localities along the route to school, oral and written, and depicted by pencil, however crude the effect would be. The country child needs a vocabulary and the power of expression. Emulation in work of this kind brought out in noting particular objects, natural or incidental, that may have historical interest, or local material interest, would often turn the imagination away from the distant and more brilliant occurrences in the towns

and cities to their own home surroundings and a germ of pride of nativity, thus implanted would outlast many more pretentious devices for securing the same end. The cultivation of the powers of observation—often called another sense, and of tracing the indications of unusual and curious natural formations to their ultimate meaning would tend to strengthen that recognition of a Higher Power innate to the human soul, develop the desire to become allied to the hidden influence that moves Nature's forces, and thus to form the true patriot, the worthy citizen, the humble Christian, as well as the accurate and logical thinker.

Two sets of the mental powers would be exercised by such methods—the external, or observing sense, and the internal, or reasoning sense. So, too, the country pupils should be taught something of the labor problem, of the relations of the wage earner to his employer and of the reciprocal duties of the State and the citizen. These processes, almost entirely ignored, because impossible under present conditions, would make enormous additions to the intellectual stock of the country child and would have an influence on the home.

The environment of the country school is favorable to the evolution of the scientist, whether in the natural sciences or in the learned professions. It is favorable to the evolution of the thinker in every line. It is favorable to the evolution of the artist and of the citizen. What these waiting forces want is opportunity; the school is the opportunity. The power of early impressions is beyond computation, and if a natural gift or tendency is reinforced by the suggestions of a wise teacher in the earlier developing stage, Pennsylvania would soon take first rank in education among her sister States.

SOCIAL INFLUENCE OF A CENTRAL CONSOLIDATED SCHOOL

Country life in the remoter districts tends to repression. One of the strongest attractions of the town for the country child, is in the greater opportunities for companionship found there. Not only the child but the elder feels the drawing of that instinct which leads mankind to rejoice in association with each other. The dozen or more schools of various sizes scattered over the country district, some difficult of access from rough and unsafe roads, often situated in a neglected and out-of-the-way spot, have little incentive to join forces in the school exercises or to impress their work on the homes and social interests of the neighborhood. Singly and detached, they cannot generate the power to penetrate the lives of the several groups that compose the pupils, or to serve as object lessons of the value of the true and the beautiful in human helpfulness. Isolation for the young is irksome, and they early form the resolve

to forsake the dull routine of oft-covered lessons which seem to hold no promise of personal benefit. The city, with its cultured society, its atmosphere of refinement, its multitude of objects and outlets for every shade of taste and interest, appeals to the youthful nature. Here are possibilities—openings for enterprise and pleasure; here, too, are sympathetic hearts to understand their hopes.

To another class, the succession of "events" in the city gives a holiday aspect to life all too prosaic in their experience, and a comparison is to the disadvantage of the country. With a common meeting point with the mutual interest of school work and the interchange of thought and feeling, and the frequent presence of parents and friends on the special occasions sure to be inaugurated in such a school, the whole community would be uplifted and cheered.

The oft-mooted question as to how far the State should extend its jurisdiction into the home and family circle, presents itself here. This question comes into every educational advance proposed. The American people are jealous of their "rights," and so sometimes lose sight of the more weighty interests involved. "Paternalism" is an ugly word to American ears; still, under the modifications and restrictions of an enlightened public opinion, it would assume a different meaning, and work for good, if its beneficiaries could be induced to look at it from all sides. This is one of the principal objections urged against consolidation in the rural districts, that it savors of "paternalism" and "favoritism." Nothing could be farther from the truth. It tends, in fact, to just the opposite. If, under the improved social conditions suggested, where all the people of a district—not necessarily a school district, but one from convenience included in the central school, could frequently meet and witness the operation of new measures and receive themselves new ideas and new information along the line of their daily work and outlook, they would soon see what the best educators have long seen, that the best policy of the State government is to lift the people out of the rut into which they may have fallen, and the best policy of the people is to allow themselves to be so lifted.

Germany has its finger on every child in the schools. The idea is that a nation should provide for the education of the people, and it has provided for the education of the whole people—for the young in primary and secondary schools, for those more advanced, in technical schools and universities. So educated, they are broad, they are leaders of thought, they are strong in every direction and return fourfold the benefits they have received. The child feels that the great eye of the nation is upon it; that its course is followed, its development watched. It is "cared for" to that extent that the child feels—even the little child in the primary schools—the throbbing of a genuine patriotic sentiment in all its

veins. The boy exists for the school; his ideal is to be a state-appointed citizen and to share in the grandeur of the fatherland. Patriotism and industry go hand in hand to make of him a useful, a self-supporting, a religious man.

Under the consolidation plan, something of this would come about. The people and the children who have not enough resources within themselves are brought a little nearer to the State, or, it might be better to say, the State is brought nearer to the child. There would be more comprehension of mutual dependency. The city has many ways of cultivating this relationship—the country has only one, the school. The State would also have closer supervision over the school and the interests other than educational represented in it.

In minor ways, the uncounted influences of greater social intercourse would be worth much. With a common meeting point, the older and younger members of the community would imbibe something of the sweet and ennobling spirit of Nature's teaching. They would learn the true dignity of labor and the beauty of a life occupation that lies within the simpler forms of life. The farmer would often visit a school established on a basis which he comprehends, and instead of the worn-out subjects for debate, exhausted by our forefathers, he could suggest other and more vital subjects and more in the line of modern agricultural progress. "Forestry," "Good Roads," "Stock," as against "Cereal Raising," "Dairy" and "Truck" farming; these, though not so pretentious as the tariff and the currency questions, are just as important to the well-being of the State, and much nearer to the circle of rural interests. Concerning the worth of rural training, the opinion of Francis W. Parker is well worth quoting:

"No method, no system of schools, no enrichment of course of study, not even the most successful of teaching, can ever take the place in fundamental education of the farm and the workshop. No matter how good the city schools may be, or may be made; no matter how good the state of society may be, the vital reinforcements of city life that lead to progress and prosperity must always come from the sturdy stock of the farm. This fact, upon which most educators agree, puts upon the country school an immense responsibility.

* * * The country school should make farm labor and all labor honorable, should dignify it, should show that the environment of the country furnishes inexhaustible resources for intellectual life, that the child brings a loving heart to nature; that the so-called practical things of life, hard and severe labor should have their highest outcome in the cultivation of the love of the beautiful in life."

CONSOLIDATION OF RURAL SCHOOLS IN OPERATION IN NEW ENGLAND STATES AND PORTIONS OF OHIO.

As no argument is so convincing as authentic evidence, it will be interesting as well as instructive to sketch briefly, the history of consolidation as it worked its way from small and experimental beginnings in Massachusetts to its present acknowledged standing in all the New England States, portions of Ohio, Dakota and in a few places in Pennsylvania. New York also is testing it in a more or less modified form.

In following these outlines it will be well to bear in mind that rural life in New England differs from that of Pennsylvania. Nothing strikes the traveler from the middle and western States more forcibly than the comparatively small areas of what are called farms and farming districts. There is the absence of that air of thrift and plenty of nature's abundance—fields of waving grain, great barns and well-kept outbuildings so dear to the heart of the Pennsylvanian. In brief, there is, notably, the difference between the manufacturing and agricultural aspect. The same rules or plans in education and in some other things do not apply to both. There is also to the Pennsylvanian, accustomed to the township system, something confusing in the New England school nomenclature. It is misleading to hear the word town used for what in this and some other States is a township. It is not necessary to explain further the full meaning in application of the two terms, except to indicate that the term town, as it is used in one place, is totally different in meaning in another. Township division, or the township unit, as it is variously called in its application to schools, is a much more convenient system than the "district system" formerly and still in use in parts of New England and in other States.

The district system was the great obstacle to consolidation when it was first proposed.

*SOME DETAILS OF THE PROGRESS OF CONSOLIDATION OF SCHOOLS IN MASSACHUSETTS.

Like other radical reforms, consolidation of schools grew out of the immediate needs of a neighborhood or of several neighborhoods. The tendency of the youthful part of the country population to desert the homestead and follow the allurements of wealth and enterprise to wider fields, left its first disastrous effects upon the school. The "little red school house" so celebrated in local literature, so dear in its associations, and so effective in its work in the

*Compiled from the pamphlet of G. T. Fletcher, agent of the Mass. Board of Education; from the Reports of Secretary Hill, of the State Board of Education, and from private communications.

earlier history of the country, no longer answered the more strenuous demands of the time. It was at the cost of a painful sacrifice of sentiment that a change was made. In the time of stress and struggle, when New England was moulding its forces for future conquest, the country school house was the center of interest to both old and young for many miles around. The stalwart youth of eighteen or twenty found in its unpretentious but thorough teachings, sufficient intellectual equipment for the future he had marked out for himself, and there the maiden whose name afterward shone like a star in the annals of literary achievement received her first inspiration. But the onward march of progress cannot be checked by a sentiment, and the wayside school was abandoned altogether or left to so small a number that it became a mere question of economy to close it. A diminished population, a lowering of property valuation and fewer children, yet each of these a just claimant of the State's bounty. The remedy was simple, and apparently the only one, viz: to unite the small and weak schools of a town dispersed over a large territory into a few strong, well-equipped and well-graded schools, at a point best suited for the purpose.

*"Notwithstanding all the inconveniences and difficulties, we believe the only practical way to elevate schools to a higher standard is by consolidating and transferring the pupils of the rural districts to the center.

"The town of Concord is regarded generally and properly as the pioneer in this movement, to close all her district schools, primarily from educational motives, and to convey their pupils to the graded central schools. The results in Concord were observed carefully by the educators in Massachusetts, and found to be good, and many of her near neighbors have already followed her example."

From the same report we learn how obstacles were met. "Concord is a town of about 4,000 inhabitants, situated twenty miles northwest of Boston. For school administrative purposes it was divided early in the century into two village districts, and five rural districts. For many years prior to 1870, the common schools of Concord were twelve in number, occupying eleven houses. Five of these schools were placed in the central village, two at West Concord and the remaining five were country district schools for the accommodation of the outlying farming population. The district school houses were at distances from the center varying from one and one-half to three miles. At the center was the high school, to which children came from all parts of the town (township).

"These schools were taught by experienced teachers, most of whom had received a special training for the work. The influence of Colonel Parker's great work at Quincy was reflected in many of the

*Extract from a special report on the subject by Mr. Wm. L. Eaton, Superintendent of Schools in Concord, Mass.

schools. Yet the general results were far from satisfactory, and the school committee, under the leadership of their superintendent, Mr. John B. Tileston, met the emergency resolutely. A vigorous agitation procured from the town an appropriation of money sufficient to build and equip an eight-room school house at the center.

"An immediate and inevitable improvement in every quality that distinguishes a good from a poor school resulted. The school committee then turned their attention to the district schools. The center school would accommodate all the children, and the laws of the State enabled the town to raise and appropriate money 'to be expended by the school committee in their discretion in providing for the conveyance of pupils to and from the public schools.'

"The school committee adopted the suggestion, that it was advisable to close the district schools and to convey the children to the center. To carry the suggestion into effect was a difficult matter. The difficulty can be realized when it is understood that a period of nearly ten years elapsed between the closing of the first and the closing of the last of the five district schools, and that during these years the successive school boards never lost sight of the end in view, nor relaxed their efforts to reach that end. A strong conservatism existed in the districts. The idea of consolidation was novel, and raised doubts and objections that could not be met by past experience. On the other hand, it was possible for the plan to prevail in the end because the communities directly affected were highly intelligent, and formed their judgments thoughtfully and correctly. It is an interesting fact, also, that during the whole ten years of change, a majority of the committee were farmers."

Attention is called to several points in the foregoing extract:

1. The impelling motive in the action taken by the school authorities was to provide better advantages for the children, not only of the outlying districts but for the whole number of pupils who would, under the plan, be brought together in one well-graded school.

2. The movement was slow, for the reason that the school authorities aimed to enlighten public opinion and thus create a sentiment in favor of a more elevated standard in public education.

3. The movement was never allowed to drop out of public view. Every successive school report during the time of agitation for the measure, contained references, appeals and statements in regard to it. Numerous addresses were also made and the legislative bodies for the most part were in sympathy with it.

CONVEYANCE OF THE CHILDREN.

Scattered as were these rural populations, and in some cases in rough and broken country, their conveyance to the school at the center proved to be the stumbling block in the way of the proposed

reform. A halt of public opinion occurred at the point where the duties of the State seemed to conflict with the duties of the parent. As the State supplied the means, the parent or school community ought to provide in some degree the manner. The distribution of State aid would require re-adjustment. Great social inequality, or moral unworthiness and many minor considerations entered into the situation.

To illustrate: It was stated in the session of the Directors' Convention of Pennsylvania, held at Harrisburg, in 1899, that a difficulty of this nature existed in Chester county, of this State, where consolidation has been tried. Objection was made to the foreign element, notably, Hungarian.

Conveyance of children is liable to abuse by over-indulgence of whims and needless anxiety of parents. There is little danger of robbing the child of that finer fibre of independence, which is worth so much in after life as to become a question whether too much aid is not worse than too little. In some of its phases, the difficulty of conveyance is sure to confront the school board in the settlement of the central school question.

THE PROBLEM OF CONVEYANCE AS MET BY MASSACHUSETTS.

G. T. Fetcher, Agent of the Massachusetts Board of Education, gives the following results of inquiries as to how the difficulty was met in that State:

"Approximately 45 per cent. of the towns report that they give equal consideration (in conveyance) to young children of both sexes. Ten per cent. report that they give a preference to girls in their plans. Twelve per cent. consider the character of the route. Thirty-two per cent. make no discrimination as to children, schools or routes."

PAYMENT FOR CONVEYANCE.

"Payments are sometimes made to parents for the actual attendance of children, so much per day a child. Payments are most frequently made to persons hired for the purpose, or, where practicable, to steam or electric railroad companies. Some parents carry their own children for a stated sum.

"In 43 per cent. of the towns the school committee makes bargains and settles details; in 10 per cent. a sub-committee of the school committee; in 5 per cent. chairman of school committee; in 12 per cent. the superintendent of schools; in 4 per cent. by the committee and the superintendent."

NO BAD RESULTS.

"The apprehensions of the owners of real estate that a depreciation of values would result if the local schools were closed, have

proven to be groundless. The natural reluctance of parents to send their young children so far from home, and for all day, to attend the central school, has vanished. The children are conveyed in comfortable vehicles, fitted up for their accommodation. They are in charge of trusty drivers en route, and at noon they are under the especial care of one of the teachers, who has an extra compensation for the service. When it is practicable, a farmer living near the extreme end of the district is employed to convey the children. Often the farmer's wife drives the conveyance. Three two-horse barges and two one-horse wagons are in use at present. All these vehicles are fitted with seats running lengthwise, and are closed or open at sides and ends, as the weather requires. The driver starts from or near the remote end of his district and drives down the principal thoroughfare, taking up the children at their own doors or at cross-street corners.

"The attendance of the children conveyed is several per cent. better than that of the village children, and it is far higher than it was in the old district schools. This is not strange when one reflects that the children are taken at or near their own doors and conveyed to school without exposure in stormy weather. Discipline is maintained in the carriages as the driver has ample authority for this purpose. The children are conveyed from one to three and one-half miles. The cost of transportation is about fifty dollars per week. It is estimated that it would cost seventy dollars a week to maintain schools in all the districts.

"Whatever advantages a system of carefully graded schools, occupying a well-ventilated and well-cared for school house, taught by a body of intelligent and earnest teachers, co-operating to secure the best discipline within and without the school room, has over a mixed country school, *such advantages are shared alike by all the inhabitants of this town. All alike are interested in all real progress in methods of discipline and instruction* and in improved appliances to aid instruction. Superintendence becomes more efficient. The introduction of new subjects of study and of drawing, music and nature study is made possible and easy. Appliances of all kinds and books of reference can be provided more extensively and at less cost. The history of this movement in Concord conclusively shows that the success of the plan was due to its intrinsic merit, acting upon the minds of an enlightened people desirous of furthering the true educational interests of their children."

SUBORDINATE ADVANTAGES.

1. "All the children of the town meet on the same arena, test the quality each of the other, and exchange from the beginning those

influences which will mould them to act together harmoniously and intelligently in the future.

2. "All the parents of the town have an equal interest in the welfare of the two central system of schools.

3. Many families have come to live in the town because of its educational advantages. The farms that come upon the market find readier sale than before.

4. "The children from the farming districts are no longer distinguishable from the village children by a certain awkwardness of manner or address.

5. "The moral tone of the school and of the school yards has been elevated wonderfully."

FURTHER PROGRESS IN CONSOLIDATION.

In 1893, Supt. Eaton prepared a statement of the results of the law authorizing transportation for the Massachusetts public school exhibit at the Columbian Exposition. In the preparation of this report, circulars of inquiry were sent to 165 towns and 135 replies were received.

"These replies indicated a gradually increasing number of schools closed yearly. The reasons for closing were given as 'financial and educational.' It was found from this that transportation to a central school made it cheaper. * * * In other towns the desire to make strong central schools, and the purpose to give all of the children of the town better advantages, have been the dominant motives to determine consolidation. Results have been satisfactory."

Particular stress should be laid on the latter clause, viz: strong schools, better appliances, better teachers, and better supervision for all the children, for these are the most potent arguments in favor of consolidation.

In a great State like Pennsylvania, with its generous appropriations for school purposes, the financial side of the question is secondary to the great principle of equity, and actual gain in education.

EXTRACTS FROM REPORTS OF STATE AGENTS OF THE BOARD OF EDUCATION IN MASSACHUSETTS.

(State Agent G. T. Fletcher, 1893-94.)

"The exodus of young men and women to the cities of Massachusetts and to the States of the west has left many of the towns poor in people and property. The State should co-operate with the towns in securing for their children educational advantages equal to those possessed by wealthy communities. The school population has diminished in a greater ratio than that of the adults because large

families of children were common formerly, uncommon now, but the number of schools has not been reduced in like proportion to the number of children, and as a result, many schools are too small to be interesting.

"Two things may be regarded as objects to be kept in view—efficiency and economy. Means to secure these ends are comfortable and convenient school houses, necessary appliances, no more schools than are needed, intelligent teaching and skilled superintendence.

"In many towns the schools can be conveniently united by twos and threes, according to size and location. In other towns all the children can be gathered at a center, where a graded school can be established. Only in this way can the best primary instruction be secured and a high school become a possibility."

Mr. Fletcher inserts in this report the following letter from Seymour Rockwell, of Montague, for nearly thirty years a member of the school committee of that town:

"Montague, Dec. 6, 1893.

"Dear Sir: For eighteen years we have had the best attendance from the transported children; no more sickness among them and no accidents. The children like the plan exceedingly.

"We have saved the town at least \$600 a year. All these children now attend school in a fine house at the center, well equipped. The schools are graded. Everybody is converted to the plan. We encountered all the opposition found anywhere, but we asserted our sensible and legal rights and accomplished the work. I see no way to bring up the country schools but to consolidate them, making them worth seeing, then the people will do their duty by visiting them.

"SEYMOUR ROCKWELL."

(Mr. George A. Welton, Agent.)

"In many towns the process (of consolidation) is phenomenal.

"The consolidation * * * is as creditable a part of our school history as their stand in colonial days is the history of the nation."

Another Massachusetts State Agent, Mr. A. W. Edson, discusses the question of public conveyance of pupils as follows:

"There is a decided tendency on the part of intelligent and progressive communities to close the small schools in remote districts and to transport children to the graded schools of the villages, where better classification, better grading and better teaching are the rule. This is done, not so much from an economic standpoint as because of the firm conviction that the children receive greater educational advantages than in the small ungraded schools."

THE ADVANTAGES SUMMED UP IN THIS REPORT.

"1. Better grading of the schools and classification of pupils. Pupils placed where they can work to best advantage, the various subjects of study to be wisely selected and correlated, and more time to be given to recitation.

"2. It affords an opportunity for thorough work in special branches, such as drawing, music and nature study. It also allows enrichment in other lines.

"3. It opens the door to more weeks of schooling and to schools of a higher grade. The people in villages almost invariably lengthen the school year and support a high school for advanced pupils.

"4. It insures the employment and retention of better teachers. Teachers in small ungraded schools are usually of limited education, training or experience. The salaries paid in cities and villages allow a wide range in the selection of teachers.

"5. It makes the work of the specialist and supervisor more effective. Their plans and efforts can all be concentrated into something tangible.

"6. It adds the stimulating influences of large classes, with the resulting enthusiasm and generous rivalry. The discipline and training obtained are invaluable.

"7. It affords the broader companionship and culture that comes from association with large numbers.

"8. It results in a better attendance of pupils, as proved by experience in towns where the plan has been tried.

"9. It leads to better equipment in every way, reference books, charts, apparatus. All these naturally follow a concentration of wealth and effort, and aid in making good schools.

"The large expenditure implied in these better appointments is wise economy, for the cost per pupil is really much less than the cost in small and widely separated schools."

SUMMARY OF OBJECTIONS.

"1. Depreciation: decreased value of farms in districts where schools are closed.

"2. Dislike to send young children to school far from home, away from the oversight of parents.

"3. Danger to health and morals; children obliged to travel too far in cold or stormy weather; unsuitable conveyance or driver; lack of proper oversight during noon hour.

"4. Insufficient and unsuitable clothing.

"5. Difficulty of securing a proper conveyance on reasonable terms.

"6. Local jealousy; an acknowledgment that some other section of the town has greater advantages.

"7. Natural proneness of some people to object to the removal of any ancient landmark or to any innovation, however worthy the measure or however well received elsewhere."

Some of these objections are wholly frivolous; others are easily disposed of by proper forethought. The conveyance and driver should be carefully scrutinized by a constituted person. The proper clothing of the children is just as obligatory and has just as much force under any other system of schooling. The oversight of the children during the noon hour should be committed to a matron qualified for the office.

Experience has proven that property in towns committed to this plan has risen, and people have been attracted to the vicinity by the educational facilities and the influences growing out from them.

That consolidation through transportation has made progress, is shown by the tabulation of expenses for the last ten years, as given in the sixty-second report of the State Board of Education of Mass.:

AGGREGATE COST OF CONVEYANCE FOR THE STATE.

Year.	Amount expended.	Year.	Amount expended.
1888-89,	\$22,118 38	1893-94,	\$63,617 06
1889-90,	24,145 12	1894-95,	76,608 29
1890-91,	30,648 68	1895-96,	91,136 11
1891-92,	38,726 07	1896-97,	105,317 13
1892-93,	50,590 41	1897-98,	123,033 41

MORE CONSOLIDATION ASKED FOR.

"As the law has extended the minimum length of the school year to thirty-two weeks, a number of schools will not be able to maintain themselves without the co-operation of the State and town, on account of added expense." In giving these somewhat extended details of the practical bearings of the plan of consolidation and centralization of schools in Massachusetts, the purpose is to bring out the most salient points of the movement from the beginning. Particular attention is called to the fact that the reports quoted from, represent different parts of the State and different industries and conditions, showing that there is great unanimity and agreement all over the State among officials and educators.

In order to reach an element not so prominently represented in these reports an effort was made to obtain an expression of opinion (for publication) from patrons and teachers of elementary grades, and in a few cases of directors or committees throughout Massachusetts.

SUMMARY FROM PRIVATE LETTERS RECEIVED.

Consolidation in the country districts has brought:

1. Better education and more desire for it among children of school age.
2. More interest in schools by patrons.
3. Better teachers and greater sympathy between schools and homes.
4. Better health.

To the question as to subordinate or secondary effects the following replies were received:

1. "Better prepared candidates for the normal schools and colleges, so that in some cases the latter enter the sophomore class and the former can complete the course in from one to three years less time than under the old system.

2. "We think our children have gained in many ways in the last five years. We have a splendid graded school, and those of the graduate pupils who apply for situations as clerks and positions of responsibility are more in demand than such as have not had the training. But we may be exceptionally fortunate in our teachers.

3. "Social influence has been widened and reflects itself in reading circles, clubs for mutual improvement in various directions, specially in the domestic arts. In matters of taste, decoration of homes, association of adults, pupils and teachers in drawing, embroidery, photography and music. Have lectures on various subjects that come within the range of our course of study. Children are encouraged to make collections of leaves of trees, plants and insects. Nothing of this kind was done—it was not possible under the old plan." (The writer of the letter from which the above was taken is located in a town of several thousand inhabitants, noted for its progressive spirit.)

4. "The country itself has materially benefited.

(a) Roads are better. We couldn't have the school if we didn't improve the roads.

(b) Gardens and grounds are improved, and visible attempts made in utilizing what formerly was waste ground."

With three exceptions, in upwards of fifty letters the plan is approved, sometimes emphatically.

Conveyance in Massachusetts is not fully provided for by the State. The school committee is the judge of the distance or of the configuration of the country or any other question that may arise in rendering aid in this direction. In some cases parents themselves, for a consideration, carry their children—this consideration is settled by the committee—in others, advantage is taken of milk wagons or any public conveyance. Whatever method is pursued, the committee is.

to an extent, held responsible for the safety of the child. No discrimination is made in regard to sex or favoritism shown in any way.

Owing to the limitations of the act authorizing transportation and the occasional objections of parents "to do their share" toward the minimizing of difficulties, such as extreme isolation, bad roads, poverty, etc., many perplexities have arisen. These, however, need not be discussed here, as we have to do more particularly with the educational phase of the question. A recent statement and resolutions from the grand jury of Franklin county covers much of this ground and will serve a good purpose in other States where similar problems may arise. (See Appendix.)

CONSOLIDATION IN CONNECTICUT.

The example set by Massachusetts was followed by Connecticut in 1889.

In 1893, the towns of the State were authorized to appropriate and expend money to convey children to and from the public schools. (The text of the law is given in Appendix.)

The substance of the law relating to Town Management (the term given to express consolidation) is:

1. *The town for school purposes becomes one district.* The existing district lines become lines of attendance, and may be changed to suit the exigencies of school attendance.

2. *Town officers, called the town committee, manage the school.*

3. *School houses become the property of the town.*

4. *The expense of schools are paid directly by the town instead of indirectly through the districts.*

5. *The business pertaining to schools is transcribed in town meeting.*

It should be noted:

1. *Schools are not abolished nor united.* Under the general law which applies to all towns, the school visitors can close any school and send the scholars to adjoining districts.

2. *Schools are managed just as roads, bridges and the poor are managed—by the town.*

6. *The town does not assume district debts.* Districts can maintain their organization for the purpose of paying debts, or the town can by vote assume the debts, but the vote to consolidate does not carry either plan.

TOWN MANAGEMENT IS ECONOMICAL.

"The towns acting under this system, spend less for each scholar in attendance than the average for the State. It cannot be said that school expenses will be less, but it can be confidently asserted that the same sum will produce better results. The object of the school system is to educate the most children in the best manner,

in the shortest time, and the town management is the most economical plan of working to this end. Wages of teachers can conform to skill and experience. Repairs can be made so as to prevent waste. The schools managed as town institutions are of sufficient importance to secure interested care. A current of vitality is sent through every part of the educational machine; a new bond is formed and isolation ceases to confine and crush the education of children. There is co-ordination, a working together of all the parts to a fit end."

(The above is taken from Sec. Hiens' condensed report—Town Management of Schools.)

Attention is called to the completeness of the law regulating the consolidation of schools and transportation of children in Connecticut. Under the twenty-seven sections are treated every bearing that can come into the situation, especially the manner of holding elections on the question. Every possible point seems to have been considered, so that the liberty of the individual or the independence of a community should not be trenched upon. As regard transportation, the authority was largely permissive. * * * The change was found to work well and also a gain economically.

Taking the town of Enfield as an illustration, the following schools were abolished:

No. 12, with an average attendance for the previous four years of eleven scholars, cost the town \$267.25 in 1893.

No. 10, with an average attendance for four years of seven scholars, cost \$278.15 in 1893.

No. 9, average attendance for four years of thirteen scholars, cost \$277.96 in 1893.

No. 6, average attendance for four years of thirteen scholars, cost \$338.00 in 1893.

No. 11, average attendance for four years of six scholars, cost \$253.15.

Here were six schools, with an aggregate average attendance of sixty-two scholars, costing the town \$1,689.55 for the school year. To transport these scholars for the year 1894, it cost \$1,045.00, a net gain of \$644.55. This saving in money is an item well worth considering, but more important still is the fact, that we have placed these scholars in schools where the advantages in all ways are superior to their old schools.

The summary, as regards conveyance of children, taken from a tabulated statement in the Report of Board of Education for 1900, is of interest:

1 The number of schools closed,	85
2. The number of scholars conveyed,	773
3. The expense,	\$10,752 38

In reply to the question if the plan was satisfactory, the table shows:

Not replying directly,	13
Satisfactory,	21
Satisfactory to "most," or "generally,"	12
Not satisfactory,	3

In reply to inquiry whether beneficial to schools:

Not replying directly,	15
Beneficial,	33
Not beneficial,	1

The financial arrangements include:

Payments to parents by town, dependent upon distance or attendance.

Payment of car fare (or other public conveyance) by town.

Town hires horse and carriage by day.

Town owns vehicle and hires driver.

Town contracts with individuals by day or year.

Facts for the two years reported:

Year.	Number of towns.	Number of schools closed.	Number of children conveyed.	Expenses.
1897-8,	44	84	849	\$11,416 25
1898-9,	49	85	772	10,752 88

CONSOLIDATION IN NEW HAMPSHIRE.

There is probably not another State so beset with difficulties as regards public school education, as the sturdy, rock-ribbed little State of New Hampshire, the paradise of the tourist and of the manufacturer. To the traveler from the southern and middle States accustomed to the softer outlines of his native landscape, the perpetually recurring query is: How are these dwellers amid Nature's fastnesses reached for purposes of education and social culture? The towering hills, overhanging cliffs, streams, lakes and forests which give the State its well-deserved title of "The Switzerland of America," would seem to debar the communities sheltered among them from ordinary rules of access and intercourse. Yet, from amid these

recesses of valley and hill have come men and women noted for the highest qualities of the human mind.

Here the consolidation of the outlying schools, reduced in numbers by the city-ward tendency, became a self-evident necessity. Several causes combined to make it the only available resource:

1. Inaccessibility and vigorous climatic conditions, making long distances for children an impossibility.

2. The lack of trained teachers, who naturally preferred the higher salaries and more genial surroundings of greater centers of population.

3. The constant demand for labor in the numerous factories and business enterprises, so that the children of the poor were put to work in the face of humanitarian protest and often of legislative action. This subject, however, does not come within the range of this article except as incidentally showing how consolidation, compulsory school attendance and the necessary supervision growing out of the case, go hand in hand toward removing evils sometimes thought to be beyond remedy.

(From report and private communication from Superintendent of Education of New Hampshire:)

"The city of Dover contains about 2,000 children. Formerly had ten rural schools, from one and one-half to five miles from center. Six of these have been closed and children are transported daily to and from city graded schools, at an expense to the city of about \$1,700 annually. The city thus saves about \$1,000 per annum.

"The small children are placed in the same building, and a matron employed for a nominal sum to take charge of them during the noon intermission, while the teacher is absent."

Results:—

1. Economy.
2. Better teachers.
3. Better supervision.
4. Greater regularity of attendance and greater punctuality.
5. Better educational spirit in and out of the school.
6. (On the community within limits affected by transportation)—
Better roads, literary organization, local enterprises.

The New Hampshire State law allows 25 per cent. of school money to be used for conveying children to and from school. The expenditures vary from 1 to 24 per cent. Tradition, habit and natural conservatism cause some opposition to the plan. Some towns pay the children, living at a certain distance from school, a few cents per mile, and leave individuals to determine the manner of conveyance for themselves, governing the payment by the attendance record of the school registers.

(From the Report of Public Instruction of New Hampshire:)

"In three given rural schools, the aggregate enrolment is fifteen and the three teachers are receiving salaries at the rate of \$906.00 per year, or an average of \$66.40 per pupil on the total enrolment. The other expenses paid by the school committee for the three schools brings up the amount to \$1,000.00, or an average annual cost of \$73.33 for each of these fifteen children, not one of whom is of a grade equal to the higher grammar school classes."

It may be seen how the State was literally forced by existing conditions, which possibly could not be paralleled in any other State, to try some other way of bringing the State appropriation to the child in profitable form.

The law in New Hampshire does not make it obligatory upon the committee to convey any children to school. It is permissive only. In all the cited cases the people are better satisfied than they would be with an independent school, under the former system.

The same system as presented in these three representative States prevails in Vermont, Maine and Rhode Island. In each one, account has been taken in necessary legislation of many varying circumstances in what may be termed the material environment of the population, such as pursuits and industries, number of wage earners and other considerations, which will readily occur to the rational inquirer. Such considerations affect most, that part of the system which falls under the necessity of the conveyance of the children.

In a number of other States attention has been given to the same method of counteracting, to some extent, the outflow of the country population, and the movement is progressing more or less rapidly in parts of New York and Ohio. The experiment—if experiment it may still be called, since it has become an acknowledged success—now going on in Northwestern Ohio is of great interest, as to some minds, the more recent movement might have greater weight than those of an earlier period.

(Extracts from the report of Mr. L. E. Morrison, Superintendent, of Kingsville, Ashtabula county, for 1895-96:)

"The new school system, which is known as the Kingsville system of education, has been formulated and introduced with marked success.

"By this system the pupils of the sub-districts are given the same advantages for obtaining an education as the village pupils, and this result has been obtained without working any disadvantage to the village pupils, for we have been enabled to open a new room and supply another teacher in the village schools, thus reducing the number of grades in each room and giving all the pupils better school advantages.

"The pupils of the sub-districts have not only been given the advantage of more extended associations and larger classes with which to recite, but they have also the advantages of a school where the teacher has fewer recitations and can give more time and attention to each recitation; thus, the pupil's progress is much more rapid than is possible in a school where there are three times as many classes and one-sixth the number of pupils. * * * It is a pleasure to note that the attendance in the sub-districts that have availed themselves of the new system, has increased from 50 to 150 per cent. in some cases, and a larger increase in all cases. The daily attendance in the same sub-districts has increased from 50 or 60 per cent. to 90 or 95 per cent., thus increasing greatly the returns from the school fund invested. This has been accomplished at a saving of more than one thousand dollars to the taxpayers in the three years.

"Since the schools were centralized the incidental expenses have decreased from \$800 to \$1,100 per year, to from \$400 to \$600 per year. All other expenses have also decreased, which may be seen from the following table:

EXPENDITURES OF THE BOARD OF EDUCATION OF KINGSVILLE, OHIO.

1889-90,	\$3,248 05
1890-91,	3,716 23
1891-92,	3,183 54
<hr/>	
Total for three years,	\$10,147 82
<hr/>	
1892-93,	\$3,153 44
1893-94,	3,072 73
1894-95,	2,831 21
<hr/>	
Total for three years,	\$9,059 37
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"In giving these figures we have deducted the \$600, with interest, which was borrowed in 1889, and has been paid during the past three years."

(Extracts from the report of Mr. J. B. Adams, Superintendent of Madison township, Lake county, O.)

"Acting upon my suggestion, the board, having in view only the best interest of the children for whom our schools exist, voted to consolidate three sub-districts at North Madison, No. 16 and No. 3 with No. 12, and also three at Unionville, No. 10 and No. 11 with No. 4, arrangements being made with the school board of Harpersfield township whereby the pupils of sub-district No. 1 of said township might attend the school of Unionville upon payment by the Board

of Education of Harpersfield to the Board of Madison township the sum of \$140 tuition.

"Our school opened with two teachers and with an attendance of ninety-three pupils. From No. 10, in which sub-district there had been the previous year an attendance of only ten pupils, there came eighteen; from No. 11, in which there had been an attendance of only eight pupils, there came eighteen, and from Harpersfield district, in which there had been an attendance of fourteen pupils, there came twenty-three. The number of pupils enrolled in this school was 107, with an average attendance of seventy-three."

Results:—

1. A much larger per cent. of enumerated pupils enrolled.
2. No tardiness among the transported pupils.
3. Irregular attendance reduced, the per cent. of attendance of transported pupils from two sub-districts being each 94 per cent., the highest in the township.
4. Pupils can be better classified and graded.
5. No wet feet or clothing, nor colds resulting therefrom.
6. No quarreling, improper language, or improper conduct on the way to and from school.
7. Pupils under the care of responsible persons from the time they leave home in the morning until they return at night.
8. Pupils can have the advantage of better school rooms, better heated, better ventilated and better supplied with apparatus, etc.
9. Pupils have the advantage of that interest, enthusiasm and confidence which large classes always bring.
10. Better teachers can be employed; hence, better schools.
11. The plan insures more thorough and complete supervision.
12. It is more economical. Under the new plan the cost of tuition per pupil, on the basis of total enrolment, has been reduced from \$16 to \$10.48; on the basis of average daily attendance, from \$26.66 to \$16.07. This statement is for the pupils in said sub-districts, Nos. 10 and 11.
13. It is a step in the direction toward whatever advantages a well-graded and well-classified school of three or four teachers, has over a school of one teacher with five to eight grades, and with about as much time for each recitation as is needed to properly assign the next lesson.

Since this report was made, consolidated schools have been established at two other points in Madison, at one place four schools, at the other three, each with two teachers. Five teams are employed to transport pupils, at a cost of about \$1 a day for each team. Every conveyance carries about eighteen pupils. There is no trouble in transporting the pupils, even the youngest, three and one-half miles, which is the greatest distance. In 1895, there were eighteen schools

in Madison, with an average of 260; this year there are ten schools, with an average that will reach over 300. The total expense will be about the same in this township as under the old plan, but the cost per pupil will be much less.

The following advertisement illustrates the care taken in Madison township to secure suitable transportation for school children.

NOTICE TO BIDDERS.

For Transportation of Pupils of the Township Schools.

Bids for the transportation of pupils of the Madison township schools over the following routes will be received at the office of the township clerk until Friday, July 24 at 12 M.:

Route A—Beginning at County Line, on the North Ridge road and running west on said road to school, in District No. 12.

Route B—Beginning on Middle Ridge road, at residence of N. Badger, running thence west on said road to the residence of Rev. J. Sandford, thence north to school house, in District No. 6.

Route D—Beginning at Perry Line, on River road, and running thence east on said road to school house in District No. 6.

(Route E and Route F, etc., similiary defined.)

All whose bids are accepted will be required to sign a contract by which they agree:

1. To furnish a suitable vehicle, with sufficient seating capacity, to convey all the pupils properly belonging to their route, and acceptable to the committee on transportation.

2. To furnish all necessary robes, blankets, etc., to keep the children comfortable, and in severe weather the conveyance must be properly heated by oil stoves or soap stones.

3. To provide a good and reliable team of horses and a driver who is trustworthy, and who shall have control of all the pupils while under his charge, and shall be responsible for their conduct. Said driver and team to be acceptable to said committee on transportation.

4. To deliver the pupils at their respective stations not earlier than 8.30 A. M. nor later than 8.50 A. M., and to leave at 4.05 P. M.

Each contractor shall give bond for the faithful discharge of his contract in the sum of \$100, with sureties approved by the president and clerk of the board.

The committee reserves the right to reject any and all bids.

But a still more striking example of what consolidation is accomplishing in Northeastern Ohio is found in the schools of Gustavus township, Trumbull county, and a visit to this place will amply repay the interested inquirer, not only as to general methods in rural school work, but will make a convert of the most doubtful to the plan.

Public attention was called to the experiment progressing in Gustavus township by an article which appeared in the "National Stockman and Farmer," of February 9th, 1899, over the name of J. M. Braden. The article was a concise statement of the progress and outlook of the schools in which the new system was being tried, and impressed even the casual reader that here was a remedy for some present ills in county education. Notwithstanding the fact that the article has been already widely quoted in addresses and school reports in this and other States, no apology is needed for repeating some of the statements found in it.

Prefacing his main subject with some forcible truths as to "the failure of the rural districts to keep pace with the rest of the country," the writer goes on to say:

"Gustavus township has nine sub-districts and one fractional sub-district. For over twenty years there has been a varying attendance of pupils per district, ranging from five to thirty, with occasionally a full term of school taught with less than five pupils enrolled in some districts. The expense of running the schools and keeping buildings repaired, has been about the same as when there was a full attendance in all districts. * * *

"So favorable have been the results of centralization in other counties, that last winter our legislature extended the privilege to all by revising 3921 of our school laws, making it possible for the boards of education to bring the pupils of a township together at some central point.

"After the legislature revised the law, our board decided to make a practical test of the new system and to that end passed a resolution to issue bonds to the amount of three thousand dollars for a new school building and went before the people at the spring election, when the measure carried.

"After the spring elections, the new board employed an architect, settled upon plans for a building, issued bonds and purchased a site. (The building put up is hereafter described.)

"The sub-districts were suspended and the board divided the township into routes for conveying the pupils. These routes were let to the lowest bidder, the successful bidder being required to give bond for the fulfilling of his contract, and also for the good conduct of himself and of the pupils carried, and further, to provide good, comfortable, well-covered vans in which to carry the children.

"Also to furnish blankets and robes for the same. The vans carry, on the average, about twenty pupils each. The children step into the vans at the roadside and are set down upon the school grounds. There is no tramping through the mud and snow. The longest distance traveled by any of the vans is about six miles and the shortest about three miles. The average cost per van is \$1.09 (cost has been

changed last year). Our school has been in session several months and we are pleased with the results.

"But there are far better results to come, when we remember that with the centralizing of our schools will come a regularly graded school, with all modern facilities for the advancement of our youth, until our schools will stand upon an equal footing with the high schools of our cities. The poor man who has only been able to send his children to the district schools, will have the pleasure of seeing his children securing the best education that can be provided by the township."

Following the interest created by the above article, which presented the subject in the most forcible and practical light, in a State where rural conditions are similar to Pennsylvania, a visit for personal inspection of the schools was made November 8th of this year.

RESULTS OF INSPECTION.

Gustavus township furnishes possibly the most satisfactory example of consolidation in a wholly rural district that can be found anywhere. The school is well organized, the outward bearings of the question are open to examination, and an insight is obtained that no amount of theoretical speculation could give. There is also the pleasure of observing the interest and enthusiasm that can be brought to pervade a genuine rural school, conducted on a common sense basis, as in this case, giving a reflex of the sincere and wholesome uplift of a country community. To an unaccustomed eye, it was a spectacle worth going far to see.

The morning was cold and stormy and it was impossible not to make involuntary comparison with other school children in the outlying districts of Pennsylvania making their way along muddy roads to school, possibly to have a shivering wait for the teacher to open the door.

The spirit manifested in the regular school work reflects great credit upon the teachers, who seem to have caught something of the new idea in teaching, as part of the new system. Not only this, but the social and home life of the vicinity has been touched by the new order of things. The value of the personal equation in school work was never more fully illustrated than in the school of Gustavus. The whole township is centralized. It is wholly a rural township, the little town of Gustavus at the center being only a small cluster of houses. A frame building, with four rooms, has been erected at a cost of \$3,000.00. Four teachers are employed. The superintendent receives \$80.00 per month; the teachers in elementary grades average \$28.33 per month. Nine vans convey the pupils to and from the school.

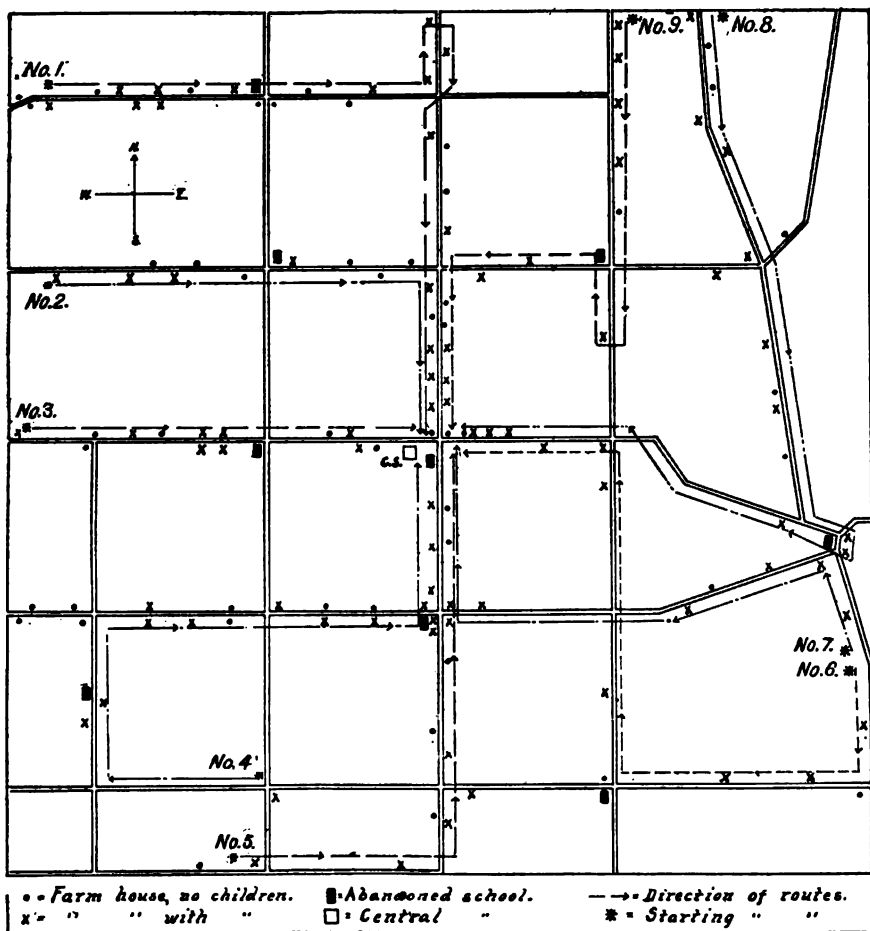


Diagram of Gustavus Township, Trumbull County, Ohio, Showing Transportation Routes. The routes pay as follows:

Route.	Amount.	Miles Travelled.
No. 1,	\$1 55 per day,.....	5 miles.
No. 2,	98 per day,.....	3¼ miles.
No. 3,	69 per day,.....	2½ miles.
No. 4,	1 50 per day,.....	5 miles.
No. 5,	1 25 per day,.....	3¼ miles.
No. 6,	1 45 per day,.....	4½ miles.
No. 7,	1 40 per day,.....	4½ miles.
No. 8,	1 48 per day,.....	5 Miles.
No. 9,	95 per day,.....	3½ miles.

For the purpose of keeping up the present system of running the schools and paying off the school-house bonds, a levy is made of nine mills on a valuation of \$370,000.00.

Besides the teaching force, the school has one janitor, who attends to the care and heating of the building. His salary is \$12.50. Reference to the tabulated report (see page 519), kindly prepared by Supt. C. L. Harshman, will give full information as to cost, attendance and progress of the school since its establishment in 1897. The van drivers are under bonds of \$200 for good conduct, comfort and safety of pupils, on the route to and from school, punctuality and regularity in transit.

To insure the proper discharge of these duties, the board of directors keep back one-half month's pay in addition to taking bonds.

SYSTEM OF CONVEYANCE POPULAR.

Men in Gustavus township are anxious to build vans and to bid on contracts to convey pupils. No trouble has arisen in any way. The vans cost from sixty to eighty dollars and are as comfortable as they can be made. The utmost regularity is required in delivering the children. Four minutes from the time the bell was tapped for dismissal the children were gone in the vans. Order and precision of movement akin to that of a military training school was observable. No confusion, no noise or scurrying for precedence in order of going or for seats in the vans.

THE SCHOOL FROM ITS EDUCATIONAL SIDE.

The school is divided (see report) into four grades. High school, grammar, intermediate and primary.

STUDIES PURSUED IN HIGH SCHOOL.

Freshman.	Sophomore.	Junior.	Senior.
Arithmetic. Language. History. Physiology.	History. Physical Geography. Rhetoric. Civics. Algebra.	Algebra. Geometry, Plane. Latin Grammar and Reader (22 weeks.) Literature.	Physics. Latin, Caesar, 4 books, Prose Comp. (more added this year). Geometry, Solid. Botany. Common branches re- viewed.

ANNUAL REPORT OF THE
GRAMMAR DEPARTMENT.

Off. Doc.

D. Grammar.	C. Grammar—Advanced Work.	B. Grammar—Advanced Work.	B. Grammar—Advanced Work.
Reading. Spelling. Writing. Arithmetic. Language. Physiology and Nature Work. Geography.	Reading. Spelling. Writing. Arithmetic. Language. Physiology and Nature Work. Geography.	Reading. Spelling. Writing. Arithmetic. Language. Physiology. Geography. History.	Reading. Spelling. Writing. Arithmetic. Language. Geography, Adv. History. Physiology. Nature Work—Review of Special Courses.

The primary course leading to the higher grades is very thorough and covers four years. (See Appendix.)

SPECIAL COURSES OF STUDY.

Oral geography for third year pupils: From directions, compass—location of objects, definitions, natural objects, etc.—to State officers, government, laws, etc.

Physiology in all grades. From laws of health, personal habits, cleanliness, etc., to effects of alcohol and narcotics, with special readings on subjects.

Review work in seventh year from nervous system to purity of life and strength of purpose.

Nature work for all grades.

Modifications to suit age and attainments of pupils.

Special readings throughout above courses.

In regard to report, it should be noted: The annual enrolment was larger under the old system, but the daily attendance was less.

Very often in good weather the little children from four to six were allowed to attend school. This would bring up the total enrolment and also add on daily attendance. The per centage of attendance on total enrolment has increased one-seventh, or 15 per cent.

Steam heat; cost for fuel last year, \$50.00.

Of the eight girls of graduating class, five got county certificates and are teaching. Gustavus sends sick children home at board's expense. This has occurred four times in three years.

MAIL DELIVERY.

The delivering of mail for the whole district, while the term of school lasts, is provided for by the vans. Before school is dismissed the principal sends one of the pupils to the post-office for the mail,

and it is distributed to each driver, who delivers it along his route. This is a great convenience to the people of the district. The drivers also bring in the mail in the morning.

GAINS UNDER THE SYSTEM.

Better health.

Less wear and tear of clothing, shoes, etc.

Better conduct, no profanity or quarreling.

Statement of Supt. Harshman is as follows:

"Only system to keep boys in schools. Under old system, boys drop out before reaching higher grades. The enthusiasm and interest have so increased, together with the more extended course of study, that boys desire to reap full benefit."

REPORT OF SCHOOLS OF GUSTAVUS TOWNSHIP, TRUMBULL COUNTY, OHIO, FOR THE YEARS 1897-1900, ALSO AN ESTIMATE OF 1901, BASED ON FIRST TWO MONTHS OF YEAR.

Public Schools of Gustavus Township, Trumbull Co., Ohio.	Old Plan.		New Plan.		
	1897.	1898.	1899.	1900.	1901.
Statistics for the School Years ending August 31,...					
Total enrolment in all schools,	210	211	193	188	*180
Average daily attendance in all schools,	128	139	144	144	*145
Per cent. of attendance on total enrolment,	66	66	75	77	
Number teachers employed in high school,	1	2	1	1	1
Number teachers employed elementary schools,	9	27	3	3	3
Total number teachers employed in all schools,	10	9	4	4	4
Average wages paid in high school,	\$50.00	\$50.00	\$62.50	\$80.00	\$80.00
Average wages paid in elementary schools,	\$24.00	\$25.00	\$25.00	\$27.50	\$28.33
Number vans for transporting pupils,	0	12	8	9	9
Total cost of schools, including bonded debt and interest paid,	\$2,975	\$3,955	\$3,225	\$3,550	\$3,550
Bonded debt and interest paid,	0	0	\$450	\$435	\$420
Net cost of schools,	\$2,975	\$3,955	\$2,575	\$3,115	\$3,130
Average cost per pupil on daily attendance,	\$21+	\$21	\$20-	\$21	*\$21
Number months of school in high school,	6	6	8	8	8
Number months of school in elementary schools, ..	8	8	8	8	8

* Estimated on first two months of year.

† Two sub-districts were hauled to adjoining sub-districts.

‡ Under new plan two more months of high school.

An objectionable feature of the present method of giving out contracts for conveying of children, is the lack of specifying certain contingencies that might arise. Where a person moves into a neighborhood after contract is given, locating beyond a point limit specified, the driver can refuse to go out of his road without extra compensation or beyond the prescribed limits, and the child is thus left to the alternative of going to meet the van at some convenient point or the board is forced to provide in some way for its transfer. There should be in such cases a special clause provided in contracts.

As to cost of building as on plans the estimate is \$3,500.00. This would give a building large enough to accommodate 180 to 200, or even 220 pupils, with four school rooms and one recitation room, four large cloak rooms, extra wide stairs, large entrance hall, two large basements and heater and storage rooms, all well lighted; two outside and two inside entrances to basement; girls' and boys' basement separate.

EXTENSION OF CONSOLIDATION.

Consolidation has been found so satisfactory in Gustavus township, that Greene township, adjoining it on the west, has centralized and built a central school building at a cost of \$7,000.00, in which, school is now being held.

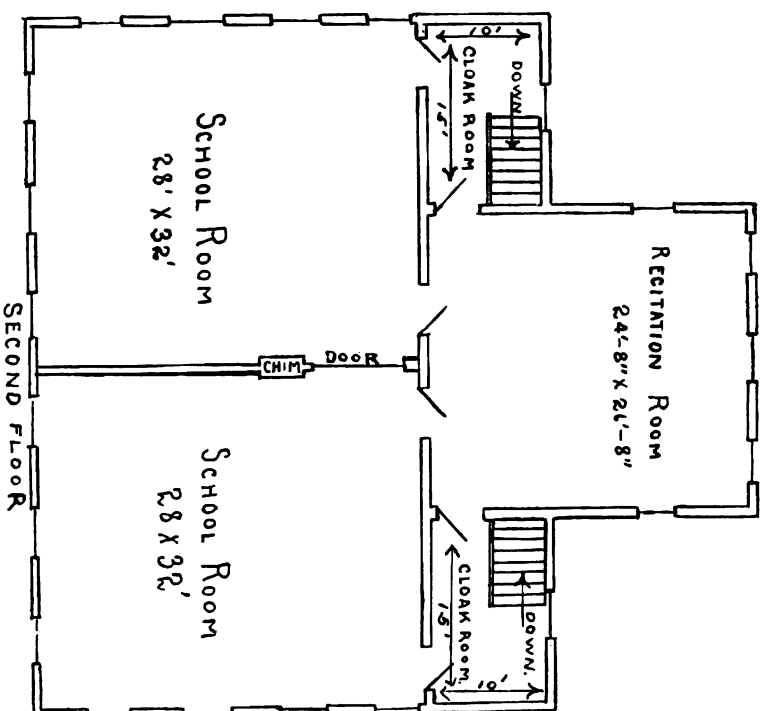
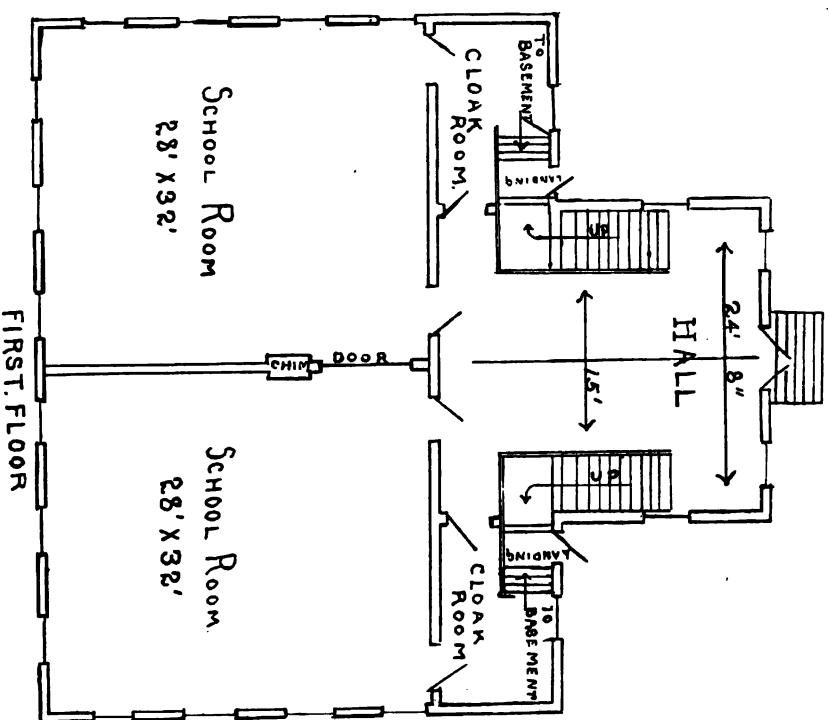
Wayne township, Ashtabula county, on the north of Gustavus, has voted for centralization, and they are now building a school to cost \$5,000.00. Kinsman township, on the east, has voted for centralization and will build next summer.

The State Superintendent of Illinois and the County Superintendent of Winnebago county, Ill., visited the schools of Gustavus in October of the present year. During their visit, the districts operating under the centralized system, were thoroughly investigated and the conclusion arrived at was that "this is what people in the rural districts have been waiting for."

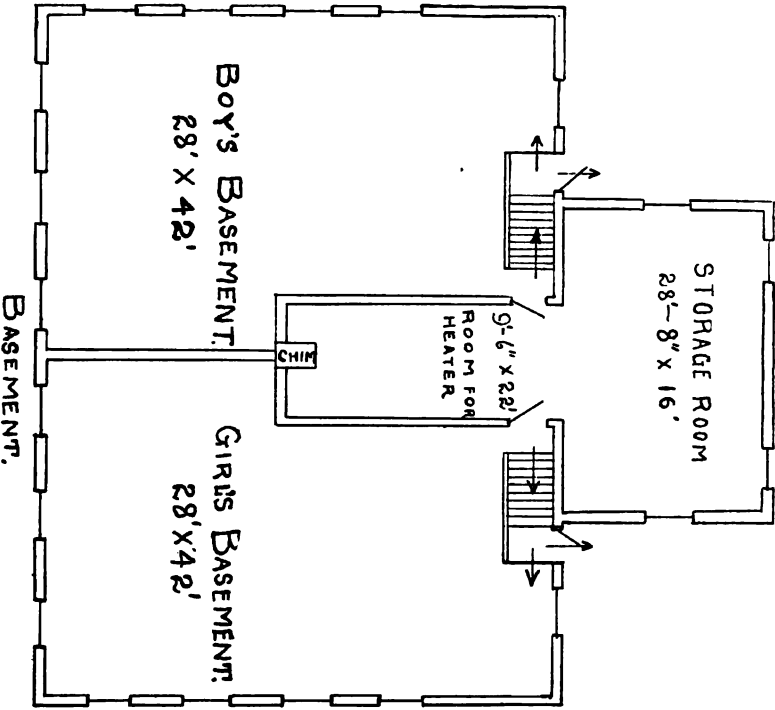
Supt. Bayliss, of Illinois, says, among other advantages: "Socially, the advantage is very great. It extends the acquaintance of the children and gives them the increased interest and enthusiasm and confidence which comes from numbers, unites the people of the township and equalizes opportunities." He concludes: "The Ohio plan can certainly be introduced to advantage in many Illinois townships." Wisconsin and Iowa are at work on it. Inquiries have also come from Kansas, all showing that people are waking up to the necessity of doing something more than has been done for rural education.

The board of education of Nelson township, Portage county, Ohio, appointed a committee to visit Gustavus for the purpose of investigating the plan of school centralization. In order to get an impartial report, the committee was made up so as to represent both sides of the question. In the course of this investigation, a canvass of the township was made for the purpose of getting public opinion on the subject. Of 54 instances interviewed, 43 were in favor of the system, 4 indifferent and 7 against. Of the 7 against, 6 were without children in attendance.

Many circumstances combine to make Gustavus a typical example of successful co-operation. Courteous officials, an enthusiastic and



Diagrams of Township Consolidated School, Gustavus Township, Trumbull County, Ohio.



Scale 1/6 to 1".

magnetic spirit at the head, thoroughly trained teachers as assistants and an appreciative community.

Valuation and Tax Rate of Gustavus and Green Townships.		Tax Rate for School Purposes.
Gustavus valuation,	\$578,000	Rate, 9 mills on the dollar.
Greene valuation,	261,000	Rate, 12 mills on the dollar.

The State appropriation is about \$400 for each township.

Gustavus pays \$3,000, in the annual payments and interest, and Greene \$6,000 in six, which explains Greene's higher rate of tax.

EXPERIMENTS MADE IN CONSOLIDATION IN PENNSYLVANIA.

Some experiments in the consolidation of schools have been made in Pennsylvania. They have not been true tests, however, of the practical value of the system, being partial and tentative in character. The mere joining together or uniting of two or more schools for convenience or other reasons of a temporary kind, is not consolidation in the true sense of the word. Such schools as unite in this informal manner can as readily disunite, and the good that has been gained will speedily be lost or dissipated by a return to the old system. A school of this kind, though it may answer a good purpose for the time being, is not a permanent part of the school machinery of the district in which it exists. It is merely an expedient. For this reason, the people who would most benefit from it are distrustful of its efficiency and, in many cases, actively oppose it.

It is looked upon as an innovation, or one of the many "fads" foisted upon the rural school in modern times. Two questions from different standpoints convey the impression the question makes on the minds of some. The first was, "will there be a whole 'system' of new books to get?" The other, "would the child be taken away from home altogether?" It is hard to think "such things can be"—in Pennsylvania.

It is really the simplest of all ways of educating by public instruction. Less machinery is connected with it than any other, and, consequently, fewer complications in the way of appointing teachers and fixing salaries. What is wanted is:

DEFINITE LEGISLATION.

The statement has frequently been made that Pennsylvania has "law enough to cover the case," in consolidation. This is not quite

true, or rather it may be said that the legislation provided falls short of the case. Pennsylvania has the township system; that is one step. The high school act of June 28th, 1895, is another step—in intention. (See Appendix.)

If the provisions of this act were fully carried out, it would still fall short of providing a higher education for the rural districts, for the reason that in very few townships could the necessary advance be made in order to reach the provisions of that act. Besides, transportation of the children is not included in the act. The course of study named in this act is not entirely suited to the wants of the rural districts, broadened as they have been by industrial and commercial conditions and by the more exacting requirements of the higher institutions of learning. Thus, the high school act becomes in effect a dead letter.

What the rural school needs, is provision for a course of study at once flexible and comprehensive and adapted to the wants of the country, for the great class with agricultural instincts and who, with better knowledge, would improve their surroundings, and for the class that seeks other fields for enterprise. In the great majority of the rural districts of our State, this great class have no chance for any advanced education in applied science, in civil engineering, in mechanical engineering, in mining engineering and kindred departments, and very little chance in any other, and if the elementary course does not lead up to it, they never can attain their desires of a higher education, yet the experience of the world proves that from these ranks, disciplined by poverty and invigorated by contact with nature from early youth, comes the greatest part of the genius and talent and energy of the world. For such as these there is no legislation in Pennsylvania, the towns and cities providing it for themselves.

TRANSPORTATION OF PUPILS.

Under another act (June 22, 1897), partial provision is made for the transportation of school children to the public schools of the district in which they reside, or to the schools of neighboring districts. (See Appendix.)

Section 1 “permits the school directors, by an affirmative vote of the majority, to provide transportation for the children at the expense of their respective districts to and from any school in the district in which the children have their residence, or of neighboring districts: Provided, That this act shall apply only to the pupils of schools which have been closed by reason of small attendance, and, Further, That it shall apply only to pupils having a greater distance to travel or are placed at greater inconvenience by such closing, and

Further, That the cost of transportation per pupil shall not exceed the cost of maintaining per pupil the schools thus closed."

The limitations and divisions of this act, as it stands, open the way to differences of opinion over the question as to the precise meaning:

1. Of what shall constitute a small enough number of children in attendance in order to make obligatory the closing of a school.

2. As to what is the exact distance which makes this clause applicable to a given case.

In regard to a similar ambiguity as to what a "reasonable distance is," Secretary Hill has this to say: "Little children should not be made to walk over a mile, although older children of grammar school age, may walk a mile and a half, or even more.

"If, for little children the mile lies through lonely, unfrequented, wooded or difficult roads, it would be too great or too dangerous a distance for them to walk.

"The State Board of Education in Massachusetts is given no authority to decide what a reasonable walking distance is. Whatever the school committee (board of directors) decides to regard as a reasonable distance for school children to walk, that is the distance they must walk."

In a lengthy analysis of the law of Massachusetts relating to transportation of children, Secretary Hill carefully defines the statutory meaning of "support," as it is variously used to include or exclude the right by the school committee to expend money for this purpose. He concludes by saying: "It needs to be stated once more, however, that whatever questions may arise as to the authority of the school committee to expend money for conveyance, such questions the committee must decide for itself, in the light of such facts and principles as are at its disposal." (Showing that doubt has not been resolved.) Comparison of the laws alluded to above with that of Ohio on the same point shows the latter has simplified the question so that little difficulty can arise.

In New Hampshire, where children or parents are in some cases allowed a certain sum per mile in payment of transportation, "the money is frequently spent for other purposes, and the children walk." The law of this State provides that town school boards may use a portion of the school money, not exceeding twenty-five per cent., for conveying children to and from schools.

In Vermont, a late law is to the effect that, upon the application of ten taxpayers in any town, the school directors shall furnish transportation to any and all children residing one and a half miles or more from any school, but the aggregate cost shall not exceed twenty-five per cent. of all the school moneys.

The New York law of 1896 provides for a tax for conveyance of pupils by vote of the inhabitants.

A law of 1894 in New Jersey and one of 1897 in Nebraska provides for transportation of pupils.

A provision of the school law of Connecticut authorizes town school boards to unite schools "when, in their judgment, the number of pupils is so small that the maintenance of a separate school is inexpedient," and provide transportation for the pupils.

The most striking instance of successful consolidation produced and the only way of satisfying doubts and preventing disputes among patrons of a school where this system comes into use, is in the *consolidation and centralization of the whole township*. The larger schools, as the smaller, are equalized. The school becomes a central point of interest for all the people of the township. There are good, bad and indifferent pupils, circumstances, degrees of intelligence and other factors from all parts brought together, treated by the same methods, taught by the same teachers, under the same humanizing and elevating influences of a school representing all the elements of a given district.

Consolidation, to be successful, must be made to mean centralization and transportation. The boundaries of the township are the natural limits of such a measure, but under careful and well defined restrictions, adjacent schools from other districts could be united under one central school.

The school should not consist of less than three teachers, the number above this depending on circumstances, over which the board of directors should have full control.

The drafting of a course of study suited to the requirements of the farm and of the general conditions of rural life—for the class that stays and the class that goes—should be delegated to a committee of intelligent and skilful educators, appointed for the purpose by the Governor of the State.

The functions of the State Medical Board are not more important to the welfare of the public than such a committee would represent.

Consolidation should be universal in all rural districts where facilities for higher education do not exist. There should be no partition of sections, or districts in townships. This is the easiest, cheapest, the simplest way to consolidate the schools. The twentieth century has this question to meet and solve.

NECESSARY LEGISLATION.

An act could be framed to meet the requirements, either by amending or supplementing existing acts, or by drawing up a new one on wholly new bases. Such an act should be so clear that no misunderstanding could arise. It should provide for the transportation of all the children of a township of school age without defining limits,

as in bad weather or in the case of young and delicate children, even a small distance would make attendance difficult, and if transportation is provided for the more distant who, in some cases are more rugged, and an additional nearby pupil would add little to the duties of the drivers and jealousies and bickerings would be avoided thereby. The act should exactly define the terms and conditions of the extent and amount of consolidation contemplated.

The act should provide for the debts and disposition of the school houses abolished, and for the building of new ones, if such are required, and for the purchase of more school ground. The act should incorporate with its provisions the new course of study and for all special features connected with it differing from the features of the present law. The act should provide for the submission of the question to the vote of the people of the township so desiring, method of voting, time and conditions relating to ballots cast being distinctly named.

Such an act should go before the people at the spring elections.

RECAPITULATION.

1. Consolidation, centralization and transportation go together.
2. Partial consolidation in a township and limited transportation do little toward providing a remedy for the educational needs of the rural districts. The whole township should be centralized—either at one or more points, according to number of children of school age or of extent of area.
3. Consolidation in the rural districts would bring:
 - (a) Concentration of resources.
 - (b) Extension of education.
 - (c) Greater attendance.
 - (d) Greater educational spirit in children and adults.
 - (e) Fit the class that goes for higher positions and the class that stays for uplifting rural interests.
4. Would have a reflective influence in health, in morals, in intellectual achievement, in material progress.

THE SCHOOL GARDEN AN ADJUNCT OF RURAL EDUCATION.

There is probably no source of Nature Study in its elementary forms, at once so accessible and attractive, as the study of plants by means of a garden on the school grounds. In the country, where

open space could be easily had and water and fertilizing material easily and cheaply obtained, no difficulty is in the way to prevent the practical success of a school garden. Other countries have led the way in providing realistic object lessons in botany and practical horticulture. In many places in Europe, school grounds, instead of being given up to play, are utilized to supply materials for study in the school room. The authorities appreciate the training which results from pruning, budding and grafting trees, plowing, hoeing and fertilizing land, hiving bees and raising silk worms. This system, modified to suit the locality, runs through the entire educational structure, down to the most elementary grade.

(Extract from an article in Appleton's Popular Science Monthly, February, 1898, by Henry L. Clapp:)

"In 1890, there were nearly eight thousand school gardens for practical instruction in rearing trees, vegetables and fruits in Austria. The Austrian public school law reads: 'In every school a gymnastic ground, a garden for the teacher, according to the circumstances of the community, and a place for the purposes of agriculture experiment are to be created. School inspectors must see to it that (the italics are ours) *in the country schools, school gardens shall be provided for corresponding agricultural instruction in all that relates to the soil*, and that the teacher shall make himself skillful in such instruction. Instruction in natural history is indispensable to suitably establish school gardens.' * * *

"In Sweden, as long ago as 1871, twenty-two thousand children received instruction in horticulture and tree-planting, and each of two thousand and sixteen schools had for cultivation, a piece of land varying from one to twelve acres.

"Still more significant, is the recent establishment of many school gardens in southern Russia. In one province, 227 schools out of a total of 504 have school gardens, whose whole area is 283 acres. In 1895, these gardens contained 111,000 fruit trees and 238,300 planted forest trees. In them, the schoolmasters teach tree, vine, grain, garden, silk worm and bee culture. They are supported by small grants of money from the country and district councils. In different provinces of central Russia the system likewise obtains."

The advantages of these gardens have been found to be so great in the country that many of the cities have adopted the idea.

"Since 1877 every public school in Berlin, Prussia, has been regularly supplied with plants for study every week, elementary schools receiving specimens of four different species and secondary schools six. During the summer, at six o'clock in the morning, two large wagons start from the school gardens, loaded with cuttings packed and labeled for the different schools. Teachers take their classes into the school gardens for lessons in botany.

"The gardens in Berlin lack many advantages to be found in the country garden. Comparatively few children can see the plants growing from seed to seed, or growing at all. The butterflies, beetles and other insects which are constantly at work on growing plants come to the notice of only a few children; consequently, their habits can not be known to many. The nature of annuals and biennials, the growth of plants from week to week, the results of varying conditions of soil, light, heat and moisture, which are so necessary to a broad and sound understanding of plant growth, cannot be properly understood if reliance is to be placed on cut specimens alone."

France has long seen the force of these conclusions and provided opportunities for practical instruction in all that relates to increase of agricultural products. In the practice of agriculture, France leads the world. In the last quarter of a century she has doubled the product of her farms. She encourages the minutia of nature knowledge. She has regard to the ultimate commercial value of the flower and of the plant that is good for food or beautiful to the eye. On certain days, the Jardin des Plantes, in Paris, is used as a place for botanical study by the school children of the city, but, besides this, gardening is practically taught in 28,000 primary and elementary schools, each of which has a garden attached to it, and is under the care of a master capable of imparting a knowledge of the first principles of horticulture. Throughout the southern part of France, the traveler sees everywhere the evidence of special aesthetic training in cultivated tracts of ground, free to the children for study and open to the public at stated hours for pleasure.

Germany, with her compact organization, has not lost sight of this important point in her vast training system. It is in this way that the youngest school child becomes impressed with the beauty and order of nature, of thrift, of the economical use of land. It is the pride of the German farmer to point to the charming outlines of the landscape, where level highways and well-kept grounds speak of industry, cleanliness and economy.

Experiments have been made to introduce a similar course in various places in this country. The wonder is that it is not universal, especially in the agricultural States. Volumes might be written to express a small part of what it would do in enhancing interest in country surroundings, aside from its educational value.

In March, 1890, as a result of the reading of a paper, entitled "Horticultural Education for Children," before the Massachusetts Horticultural Society, a school garden was established in connection with one of the Boston grammar schools. A committee of the society promised the necessary pecuniary support. In presenting the claims of school garden work, the head of the committee said: "We desire to emphasize the true idea of a school garden. Growing

plants from the first sign of germination to the full perfection of blossom and fruit, and edible roots in all stages, give constant opportunity for study."

Of plants suitable for educational purposes, the decision was: "Ornamental plants, or those commonly cultivated in flower gardens, will not stock the school gardens contemplated by the committee. Native wild plants, such as ferns, grasses, asters, golden rods, violets, native shrubs and economic plants, such as grains, vegetable roots and leguminous and cucurbitaceous plants must be the stock of the gardens."

The committee appropriated ten dollars to start the garden. A piece of ground forty-eight by seventy-two feet in the back of the boys' yards of the George Putnam Grammar School was found the most available. A few teachers offered all the assistance in their power to carry out the purposes of the committee.

It is impossible here to give a connected account of the progress made, but one visit to the garden will convince the most skeptical that one month's study of this kind is worth a year's work in the same study with only the aid of the text-book. At present, there are more than one hundred and fifty different species of native wild plants in this garden. A great many insects have been observed upon the plants—beetles, wasps, flies, moths and butterflies. Soon the garden will afford the pupils their only opportunities for studying, describing, drawing and painting such insects.

Since 1891, the Massachusetts Horticultural Society has offered every year a premium of fifteen dollars for the best school garden, in connection with the best use of it. This garden has competed with others, and won the premium every year.

EDUCATIONAL VALUE OF A SCHOOL GARDEN.

Besides the opportunities for correlation, it gives the opportunity for bringing together a great number of plants to be classified and arranged in families, genera and species. The reason for such classification becomes apparent in the grouping of plants similar in form, structure and habits. What cultivation will do by way of increasing the vigor of plants and making them blossom and fruit more freely is fully illustrated every season.

The school garden affords by far the best means for the cultivation of the powers of observation. Pupils find excellent forms to draw, colors to imitate, habits to describe and motives to use in decorative design. They find something to take care of, something that quickly responds to love's labor, and as interest is added to interest, they lay up for themselves resources for happiness that should be the heritage of every child.

Mr. Hamilton W. Mabie, in his *Essays on Nature and Culture*, says: "Once in a while some discerning man, outside of the regular school interests, sees the inconsistencies of educational systems. Relationship with nature is a source of inexhaustible delight and enrichment; to establish it ought to be as much a part of every education as the teaching of the rudiments of formal knowledge; and it ought to be as great a reproach to a man not to be able to read the open pages of the world about him as not to be able to read the open page of the book before him."

School gardens are in successful operation at Medford, at Wenham and at other points in Massachusetts; at Bath, Maine, and at various points in the west.

"In 1899 the chairman of the school garden committee visited a number of school gardens in Germany. Those established in Pössneck and Gera were particularly interesting on account of their size, complete equipment, etc. Each is not far from an acre in area. The pupils of eight grades work in the garden an hour a day. The notes which they take in the garden, serve as a basis for compositions on the various kinds of work connected with farm life. Fertilizing, rotation of crops, the effect of the presence or absence of light, heat or moisture, the birds and insects injurious or helpful to certain kinds of plants, and many other kindred topics are written upon. As a consequence, the Germans are expert farmers. A considerable amount of such work in connection with our public schools in the country would make young people more contented and successful in farming and keep them from rushing into the cities."

As showing how old new ideas are, it may be interesting to add that "the old Quaker, George Fox, in 1691, willed a tract of land near Philadelphia for a play ground for the children of the town to play on and for a garden to plant with physical (medicinal) plants, for lads and lassies to know simples, and learn how to make oils and ointments."

TOWNSHIP SCHOOL LIBRARIES.

To one unacquainted with rural schools as they most often exist, and with the conditions of rural life, it is beyond realization how the mental requirements for growth and development are met. There is positive intellectual hunger for suitable books to read in the enforced leisure of the long winter evenings. Newspapers and the cheap and sometimes questionable periodical literature are seized upon and read with avidity, but there are many who long to have access to a well-selected library, and who wisely improve such opportunities, as are afforded in profusion in the city free libraries and reading rooms.

School libraries, specially selected and well bound, are now on the market, especially adapted for country schools, and for a trifling sum, a really excellent and serviceable library can be procured.

SLOYD.

This feature of the educational system of Sweden, has been profitably adopted by many city schools and private institutions for certain grades and kinds of pupils. Working from models, making rough sketches and blue prints, with all the different processes characteristic of Sloyd work, would prove an acceptable addition to the ordinary text-book work in the country school. The country boy is early accustomed to the use of tools and implements, and he would find a keen delight in the adaptation of this system to his natural deftness in making things.

INDUSTRIAL EDUCATION.

The value of a comprehensive system of industrial education to the country child is absolutely incalculable. Simply stated, it means readiness for its future calling, fitness for special work in whatever direction natural talent or taste may point, saving of time and a higher degree of excellence in further education. The trained, the practiced hand, the mental power of gauging causes and effects, of comparison, of drawing an inference, of looking to a practical result; what amount of money, putting it upon the lowest, the pecuniary basis, could be set over against it.

The vast manufacturing and commercial interests of the country are calling for the ready hand and self-reliant energy of the specially instructed worker. The artistic and decorative industries are everywhere raising their standard of thoroughness in execution and in the conception of true ideals in art. The powers of the child are never so satisfactory as in early youth, when the impressionable brain takes note of lines and shadings, full of meaning, but apt to be lost to the more mature observer.

So the pencil and the brush should be put in the hand of the country child as early as in that of the city child. The developing taste should be encouraged from its lowest beginnings. The different seasons should give motives for plain and easy designs in decorative combinations or in simple "picture work." The fall furnishes examples of nature's profuse coloring. Leaves, twigs, seed-pods and fruits should not be neglected, as models, and for advanced classes a succession of simple forms could be united to form a harmonious design, for mural or surface decoration. Spring and summer fur-

nish numberless attractive studies in grasses and bending bud and full-blown flowers.

In many New England country schools, such a system prevails. A little time is taken each day for hand training in its various departments, and when the child leaves the threshold of its early home it is, in some degree, ready for a wider destiny.

There is a class of minds to which the classical and literary training in the best high school is not suited. Beyond the essential requirements of an ordinary education, these do not desire to go and it is just at this period that the question becomes vital; the child should be allowed to give up or to enter upon a course of further training in line with its natural taste and endowment.

PHYSICAL CULTURE.

Too little attention is given in our rural schools to physical culture. There is a pre-supposed conclusion that the country child has no need of special training in this direction. Exercise necessitated by its environment and the tasks on the farm is confounded with the idea of physical instruction in graceful and harmonious muscular movements. The proper manner of sitting and standing, rhythmic lessons in marching and rising, passing each other and a regular drill in the etiquette of personal postures, is a part of the physical education of the fortunately placed city child, giving grace and manner, often a determining influence.

SPECIAL OCCASIONS IN SCHOOL LIFE.

Country children have fewer opportunities for celebrating national or historic events. Such events properly observed, foster patriotism, besides possessing a large educational value in sending the pupil to ransacking the stores of literature in embellishment of the particular subject. A fraction of time deducted from the regular routine would be useful in giving breadth and scope to the ideas of citizenship, civic duties and the value of manhood to a country or State. Washington's and Lincoln's birthdays, Arbor Day, Memorial Day and Flag Day, should be made just as impressive to one group of children as another. Such exercises stimulate the mind to self activity and cultivate the powers of heroic imagination and true conception of the ordinary duties of life.

SOME OUTGROWTHS OF A WELL-ORGANIZED CENTRAL SCHOOL NOT DIRECTLY EDUCATIONAL.

GOOD ROADS.

Good roads are an index of civilization, and as such, may be taken as a factor in the estimate of remedies for the preservation of the country. It makes a great difference to the farmer whether he travels ten miles in one hour or in three, and whether his team can draw two tons of produce or half a ton.

Good roads mean accessibility, and upon accessibility depends the value of the farm. But good roads mean much more than the price of land or additional labor in marketing farm products. The intellectual, moral and religious conditions of the rural districts are intimately associated with the roads. The schools are likely to be better, the social life is elevated and the church is better attended and exerts a wider influence where roads admit of easy travel.

That the maintaining of a central school would have a good influence upon the roads, needs no argument to prove. It is an absolute necessity as a safeguard of the comfort of the children daily passing to and fro over them. The carriers likewise would be interested, for the wear and tear of their vehicles and security of their incurred obligations. From many letters received on this subject, indications are strong that the improvement of roads is a concomitant of consolidation.

LOCAL INDUSTRIES.

In many parts of rural Pennsylvania, there are opportunities for establishing local industries that would give employment to a number of such, as from inclination or ties of family, would prefer to stay in their rural environment, were it not for the pressure of the necessity to earn something for support. The agricultural population is necessarily limited to those who find employment in agriculture, unless some enterprising spirit "sees a chance" and succeeds in building up an industry out of the local elements found there. Many such might be named. They will occur to every one who has knowledge of the resources of this State in mineral deposits and other material sources not yet even approximately utilized. Most of these special industries require specially trained workers, as in ceramics, pottery and tile manufacture. But many of these industries referred

to, employ women. Such are those engaged in producing the lovely specimens of hand-painted books now sought after.

The art ideals of Ruskin and Morris are working their due effect in the beautiful reproductions of the illuminated lettering, and quaint printing-forms that are so interesting in their original setting. One of these has been formed at East Aurora, N. Y., a small town and of no especial importance until this industry was established there and gave it fame. The "Roycrofters," as the company is called, says, in one place: "Our business is simply to give artistic employment to the people in the village or immediate vicinity, and, if possible, show them that the country is just as desirable a place to live in as the cities."

One who visited this industry, for so it must be called, writes of it in this wise: "You are here enacting a perfect poem of labor, dedicated to the muses of beauty and health. A rare happiness and serenity result from this linking of day to day with enforced and gracious industry. Joy is lyric. The workman who sings at his bench is doing his work well.

"In the midst of a material civilization that subordinates the true nobility of life, of a head-long race for wealth that grinds the faces of the poor, you are favored to set here, in an idyllic frame, the picture of an antique simplicity. Let the world roar at a safe distance—here in this quiet and sheltered haven you are doing a task, made possible by the genius of one man, that is of vastly more import than all the hubbub and shouting yonder. You are as a voice crying in the wilderness; preaching the gospel, I would say, of content with fair and ordered industry, as against the frantic body-and-soul-destroying slavery that is miscalled labor elsewhere, inculcating by your modest example the preciousness of good living, the conservation of physical, mental and spiritual health."

Other similar art industries are connected with Miss Starr's interesting work along the same line. The more useful and practical of the women's clubs are interesting themselves in providing schemes and outlining simple plans for productive work among the women and children of the laboring class in the rural districts.

Such plans might well be propagated as an offset to university settlements in the city and which have such a powerful uplifting influence. A school, uniting and drawing out the latent special gifts of many who are all unconscious of their powers and of the opportunity that is ready for the skilled hand, would be a god-send in many ways besides those indicated in the curriculum of study.

BACK TO THE LAND MOVEMENTS.

In New Hampshire, the "Old Home Movement" is significant of the trend of opinion in that State in regard to the reclaiming of the abandoned farms.

The movement is thoroughly organized and is making headway under the leadership of State officials from the Governor down, and of prominent men in all circles of intellectual and commercial matters.

The Village Improvement Society, has for its ultimate object the rehabilitation of the rural districts of New England.

DENMARK'S DESERTED FARMS.

From a leaflet published by the Howard Association in London, England, we take the following:

"Partly by State aid and partly by private enterprise, 2,000 square miles of waste land have been reclaimed and five-eighths of the national territory is possessed by small freeholders and peasants. Above a hundred people's high schools have been established, where peasantry and working classes of ages from 18 to 25 get board and education for 10 s. per week. The Danish farmers have formed co-operative societies for the collection, sale and export of their produce. Danish university and college students have instituted throughout the rural districts, free lectures, evening lessons and committees for promoting popular amusements. In almost every village a public hall has been erected for recreation and social gatherings. In villages where the high school has obtained influence, neither drinking, gambling nor gross breaches of morals are to be met with, yet the villagers are fond of games, dancing, sports and other recreations."

APPENDIX.

ABSTRACTS OF LAWS RELATING TO CONSOLIDATION AND TRANSPORTATION IN THE STATES PARTICULARLY NAMED.

MASSACHUSETTS.

The following law was enacted in 1869:

"Any town in the Commonwealth may raise by taxation or otherwise and appropriate money to be expended by the school committee in their discretion in providing for the conveyance of pupils to and from the public schools."

CONNECTICUT.

Consolidation of School Districts.

(Gen. Stat., Title xxxv, Chapter cxxxvi, page 477.)

Section.

1. Consolidation by vote of towns.
2. Vote to be by ballot at annual meeting.
3. School business at town meetings.
4. Voting list.
5. Names of persons elected to be returned to Secretary of State.
6. When vote of consolidation takes effect.
7. Number of school committee, when and how determined.
8. School committee, how first chosen.
9. Number to be voted for.
10. Classification.
11. Powers and duties of school committee.
12. Property and duties of consolidated districts.
13. Time for payment of tax extended.
14. Proceedings where there are joint districts.
15. Permanent funds, management of.
16. School libraries.
17. Notice of abolition of part of a school district.
18. An abolished district may settle up its affairs.
19. Mode of paying debts.
20. Collection of taxes in favor of districts.
21. Abandonment of union system; vote, how taken.
22. Town to be reimbursed for improvements.
23. When vote to re-establish district takes effect.
24. Committee of consolidated district to be visitors of the town, on abandonment of town system.
25. Taking land for school purposes.
26. Payment of school expenses.
27. Distribution of school money to towns under town system.

The headings of the different sections are given in order to show how comprehensive this act is.

Section 142. "Any town may abolish all the school districts and parts of school districts within its limits and assume and maintain control of the public schools therein, subject to such requirements and restrictions as are or may be imposed by the General Assembly. * *

Section 143. "Whenever a vote shall be taken in any town in reference to abolishing school districts and assuming control of the public schools therein, such vote shall be by ballot, at an annual town meeting, upon notice thereof given in the warning. The selectmen shall provide a ballot box for that purpose, marked "Consolidation of Districts." Those in favor of such consolidation shall deposit in

said box a ballot with the word "yes" written or printed thereon, and those opposed shall deposit a ballot with the word "no" written or printed thereon. * * *

Section 198. "Whenever any school shall be discontinued under the provisions of sections 196 or 197 (reference to conditions required for abolishing schools) the school visitors may provide transportation to and from school.

Section 199. "The expenses of transportation, when approved by the board of visitors, shall be paid by the town (township) treasurer, upon the order of the selectmen."

RHODE ISLAND.

Section 8. "The school committee of any town may consolidate any schools the average number belonging of each of which is less than twelve, for the purpose of establishing a graded school; and said school committee shall have authority to provide, in their discretion, transportation for pupils to and from schools."

NEW HAMPSHIRE.

The law of New Hampshire does not make it obligatory upon the committee to convey any children to school, it is permission only.

OHIO.

AN ACT

To provide for the centralization of township schools and provide a high school for the same.

Section 1. For the purposes of this act the word "centralization" is hereby defined as a system of schools in a township providing for the abolishment of all sub-districts and the conveyance of pupils to one or more central schools.

Section 2. A township board of education may submit the question of centralization, and upon the petition of not less than one-fourth of the qualified electors of such township district must submit such question to a vote of the qualified electors of such township district, and if more votes are cast in favor of centralization than against it, it shall become the duty of the board of education, &c., to proceed at once to the centralization of schools of the township and if necessary, purchase a site or sites and erect suitable building or buildings thereon.

Section 3. All elections ordered by a board of education in pursuance of section two of this act shall be held at the usual place or places of holding township elections, at a regular or special election as may be determined by the board, and notice shall be given and the election conducted in all respects as provided by law for the election of township officers, and the ballots shall have printed thereon: "For Centralization—Yes." "For Centralization—No."

Section 4. Should the board of education deem it necessary to issue bonds to purchase a site or sites or erect a building or buildings for the purpose of such centralization, then the election shall be conducted as provided in section three of this act, but in such case the ballots shall have printed thereon: "For levying a tax to purchase ——— site (or sites) and erect ——— building (or buildings) for the centralization of schools, at a cost not to exceed \$———. Yes." "For levying a tax to purchase ——— site (or sites) and erect ——— building (or buildings) for the centralization of schools at a cost not to exceed \$———. No." And if more votes are cast in favor of levying said tax for said purpose than against said proposition, at such election it shall be the duty of the said board of education and the board of education is authorized to issue bonds and sell the same as provided by law and to levy a special tax to provide for the payment of the same, together with interest thereon; provided said levy shall not in any one year exceed five mills on the dollar valuation, and said bonds shall not bear more than six per cent. interest and shall not be sold at less than their face value.

Section 5. In a township district in which proceedings have been had under the preceding sections of this act and the vote has been favorable for centralization, there shall be an election held on the next succeeding first Monday of April for the election of a board of education, consisting of five members elected at large in said township district, one of whom shall serve three years, two for two years and two for one year, and two members shall be elected annually thereafter for a term of three years, except every third year but one shall be elected for three years. Said election shall be held at the annual voting place or places in said township by the regular election officers and shall be conducted in all respects as provided by law for the election of township officers: Provided, There shall be a separate ballot box, poll books and tally sheets, and said election officers shall receive no extra compensation for such services.

Section 6. Upon the election, qualification and organization of the board of education provided for in section five of this act, the board of education previously existing in said township district shall cease to exist and the same is hereby abolished and the board of education provided for in this act shall be considered the successor of the former township board.

Section 7. The clerk of the township shall be *ex-officio* member of the board of education provided for by this act and shall be clerk thereof; the treasurer of the township shall be *ex-officio* treasurer of the board of education: Provided, That in all other respects the law governing village boards of education shall govern and control all boards of education organized as provided by this act.

Section 8. Boards of education in township districts organized as provided for by this act are required to maintain and support a graded course of instruction and may include a high school course of not less than two years; they are also required to furnish transportation to and from school, to all pupils living more than three-fourths of a mile from the central building, said distance to be measured from the enclosure immediately surrounding their residence to the school house property, along the nearest public highway.

Section 9. This act shall take effect and be in force from and after its passage.

PENNSYLVANIA.

HIGH SCHOOLS.

Act of 28th June, 1895.

AN ACT

To regulate the establishment, classification and maintenance of high schools, the distribution of appropriations in aid of high schools, and the employment of teachers in high schools receiving State aid.

Section 1. Be it enacted, &c., That the directors or controllers of any school district may establish a public high school, and the State Superintendent of Public Instruction shall prescribe a uniform course of instruction which shall be taught in the high schools of each grade.

Section 2. The directors of two or more townships or school districts shall have power to establish joint high schools, and the expense shall be paid as may be agreed upon by the directors or controllers of said districts, who shall meet jointly so often as may be necessary for the transaction of business pertaining to the joint high schools under their jurisdiction, and all proceedings in relation thereto shall be spread at large upon the minutes of the respective boards.

Section 3. A high school maintaining four years of study beyond the branches of learning prescribed to be taught in the common schools and called the common branches shall be known as a high school of the first grade; a high school maintaining three years of study beyond the common branches shall be known as a high school of the second grade; a high school maintaining two years of study beyond the common branches shall be known as a high school of the third grade: Provided, That the reviews necessary for the prosecution of high school studies shall not be excluded from the estimate of the year's study beyond the common branches.

Section 4. From the annual appropriations in aid of high schools, a high school of the first grade shall each year receive a sum not exceeding eight hundred dollars, a high school of the second grade a sum not exceeding six hundred dollars; a high school of the third grade a sum not exceeding four hundred dollars. If the appropriation is insufficient to pay the above amounts to the several high schools, then the appropriation shall be distributed to the schools of the respective grades in such a manner that each school shall receive a sum proportional to the number of years of advance study maintained in its courses of instruction: Provided, That any high school established at the fall opening of the school year beginning on the first Monday of June, one thousand eight hundred and ninety-five, shall be paid at the end of the year as a high school of the third grade.

Section 5. The directors or controllers of every district receiving aid in accordance with section four of this act shall employ for said high school at least one teacher, legally certified, to teach book-keeping, civics, general history, algebra, geometry, trigonometry, including plane surveying, rhetoric, English literature, Latin, including Cæsar, Virgil and Cicero, and the elements of physics, chemistry, including the chemistry of soils, botany, geology and zoology, including entomology, and no teacher shall be employed to teach any branch or branches of learning other than those enumerated in his or her certificate.

Section 6. The directors or controllers of every district establishing a high school and receiving State aid in support of said high school shall, before the first day of September following the close of each school year, make to the Superintendent of Public Instruction sworn statements, giving full information concerning the teachers, classes and courses of study of every high school under their jurisdiction.

Section 7. High schools established in accordance with this act of Assembly shall be under the supervision of the city, borough or county in which they are situated.

Section 8. The courses of study in high schools receiving State aid

shall be subject to the approval of the Superintendent of Public Instruction.

Approved—The 28th day of June, A. D. 1895 (P. L. page 413, etc.).

DANIEL H. HASTINGS.

AN ACT

To authorize school directors and controllers to provide transportation for school children, at the expense of the district, to the public schools of the district in which they reside, or to the schools of neighboring districts.

Section 1. Be it enacted, &c., That from and after the passage of this act the school directors of any district, by the affirmative votes of a majority of the board duly recorded on the minutes, may provide transportation for the children, at the expense of their respective districts, to and from any school in the district in which the children have their residence, or of neighboring districts: Provided, however, That the provisions of this act shall apply only to the pupils of schools, which, in the discretion of the board of school directors, have been closed by reason of small attendance: And provided further, That it shall apply only to pupils that have a greater distance to travel or are placed at greater inconvenience than before such schools were closed: And provided further, That the cost of transportation per pupil shall not exceed the cost of maintaining per pupil in the schools thus closed.

Section 2. The expense incurred providing for transportation of school children under this act, and the tuition for education when admitted to the schools of other districts, shall be paid by the treasurer of the district in which the children have their place of residence, upon the orders of the school board of directors; and no member of the board or other official of the township, borough or school district shall be a party to any contract or agreement with the board, or receive any remuneration for services rendered to the district in conveying children to and from any school.

Approved—The 22d day of June, A. D. 1897 (P. L. No. 149, p. 181).

COURSE OF STUDY OF GUSTAVUS PUBLIC SCHOOLS.

PRIMARY DEPARTMENT.**First Year. D Primary.**

Reading—Chart, primer. Baldwin's First Year.

Spelling—Words from lesson.

Writing—Small and capital letters. Pencil.

Numbers—Combinations 1 to 15.

Language—Lessons given by teacher.

Physiology and Nature Work—Oral. See special courses.

Second Year. C Primary.

Reading—Baldwin's Second Year and Supplementary.

Spelling—Words from lesson.

Writing—Combinations of letters (pen or pencil).

Arithmetic—Milne's Elements to page 132. Omit pages 92-93, 100-101, 113-118, 132-137.

Language—Lyte's Elementary English, Part I.

Physiology and Nature Work—Oral. See special courses.

Third Year. B Primary.

Reading—Baldwin's Third Year and Supplementary.

Spelling—Patterson's Word Book to lesson 44.

Writing—Barnes' No. 1.

Arithmetic—Milne's Elements to page 132.

Language—Lyte's Elementary English, Part II.

Physiology and Nature Work—Oral. See special courses.

Geography—Oral. See special courses.

Fourth Year. A Primary.

Reading—Baldwin's Fourth Year and Supplementary.

Spelling—Patterson's Word Book. To lesson 92 and review.

Writing—Barnes' No. 2.

Arithmetic—Milne's Elements to page 188. Omit Art. 190, 198. Dobb's Mental, easier parts to page 47.

Language—Lyte's Elementary English, Part III.

Physiology and Nature Work—Oral. See special courses.
Geography—Natural Elementary to page 71.

GRAMMAR DEPARTMENT.

Fifth Year. D Grammar.

Reading. Baldwin's Fifth Year and Supplementary.
Spelling. Patterson's Word Book to lesson 144.
Writing. Barnes' No. 3.
Arithmetic. Milne's Elements to page 205 and review. Dubb's
Mental. Review to page 47, advance to page 98.
Language. Lyte's Elements of Grammar to page 109.
Physiology and Nature Work. Oral. See special courses.
Geography. Natural Elementary, completed.

Sixth Year. C Grammar.

Reading. Baldwin's Sixth Year and Supplementary.
Spelling. Patterson's Word Book. Review from first. Advance
to lesson 200.
Writing. Barnes' No. 4.
Arithmetic. Milne's Elements review and completed. Dubb's
Mental to page 125.
Language. Lyte's Elements of Grammar to Part III.
Physiology and Nature Work. Oral. See special courses.
Geography. Natural Advanced to page 61.

Seventh Year. B Grammar.

Reading. Baldwin's Seventh Year and Supplementary.
Spelling. Patterson's Word Book to lesson 280.
Writing. Barnes' No. 5.
Arithmetic. Milne's Standard to page 170. Dubb's Mental re-
viewed to page 125.
Language. Lyte's Elements of Grammar. Part III and reviewed.
Physiology and Nature Work. Oral. See special courses.
Geography. Natural Advanced, pages 62-111.
History. Eggleston's First Book.

Eighth Year. B Grammar.

Reading. Baldwin's Eighth Year and Supplementary.
Spelling. Patterson's Word Book, completed and reviewed.

Writing. Barnes' No. 6.

Arithmetic. Milne's Standard, pages 170-301. Dubb's Mental. Begin page 125.

Language. Lyte's Advanced to page 226.

Geography. Natural Advanced, completed and reviewed.

History. McMaster's to page 205.

Physiology. Overton's Intermediate.

Nature Work. Review of special courses.

HIGH SCHOOL DEPARTMENT.

First Year. Freshman.

Arithmetic. Milne's Standard. Dubb's Mental completed.

Language. Lyte's Advanced, completed.

History. McMaster's, completed. Constitution studied briefly.

Physiology. Overton's Advanced.

Second Year. Sophomore.

History. Colby's Outlines of General History—thirty-two weeks.

Physical Geography. Guyot—thirty-two weeks.

Rhetoric. Quackenbos—thirty-two weeks.

Civics. McCleary—first sixteen weeks.

Algebra. Milne—last sixteen weeks.

Third Year. Junior.

Algebra. Milne—thirty-two weeks.

Geometry, Plane. Milne—thirty-two weeks.

Latin. Harkness' Grammar and Reader—thirty-two weeks.

Literature. Watkins and Brooks—last twenty-four weeks.

Fourth Year. Senior.

Physics. Cooley's Students' Manual.

Latin. Cæsar, 4 books. Prose Composition.

Geometry, Solid. Milne—first sixteen weeks.

Botany. Wood—last sixteen weeks.

Common Branches. Reviewed—thirty-two weeks.

Rhetorical exercises throughout the twelve years.

SYLLABUS OF WORK BY GRADES.

FIRST YEAR.

Reading.

Baldwin's Primer and First Reader. There is no more important branch taught than reading. The order for beginners is: The object, the idea, the spoken word, printed word, proper pronunciation. Master the words as presented—first as a whole, second as to phonics, third as to letters. Aim to make the child independent of the teacher. See that pupils understand what they read.

Spelling.

Spell words from reader and review often.

Writing.

Strive to keep proper form before the child, but pay little attention to position and movement.

Numbers.

Use objects to give ideas of numbers. See that pupils can count, having them count objects. Teach meaning of signs. Teach objectively simple fractional parts of numbers as 1-2, 1-3, 1-4, 2-3, 2-4, etc.

Language.

Encourage pupils to talk. Have stories told by pupils after having heard them read. Correct improper use of language.

Physiology and Nature Work.

See special courses for this and following years.

SECOND YEAR.

Reading.

Baldwin's Second Year. Notice position of child. Tone of voice loud enough to be heard distinctly. Accurate pronunciation. Teach diacritical marks. Read other texts.

Spelling.

Patterson's American Word Book. Spell words from reader. Spell both oral and written.

Writing.

Notice position more than movement.

Arithmetic.

Milne's Elements. Teach reading and writing of numbers. Teach combinations of numbers.

Language.

Lyte's Elementary English. Have neat and accurate work; allow no other.

THIRD YEAR.**Reading.**

Baldwin's Third Year. See that the pupil reads in a natural matter. Waste no time in allowing the pupils to correct errors, but have the attention of the class at all times.

Spelling.

Patterson's Word Book. Review last year's work and study carefully new words. Oral and written work.

Writing.

Pay attention to form of letters. Position of child, body, head, feet, hands. Position of pen, paper. Work neatly done. One page a week.

Arithmetic.

White's Elements. Be sure the pupils understand the work required of them. Review often.

Language.

Lyte's Elementary English. Do more than the work of the book. Have some original work by pupils.

Geography.

See special courses.

FOURTH YEAR.**Reading.**

Baldwin's Fourth Year. Watch the mechanical side of reading as well as the thought getting. Test the pupils to see if they understand what is read.

Spelling.

Patterson's Word Book. Have the words used in sentences by pupils. Be sure they understand the use.

Writing.

Allow only neat work. Have practice paper for use of pupil to supply the copy-book.

Arithmetic.

Milne's Elements and Dubb's Mental. Have mental work at least one-third of time, using easier parts of mental.

Language.

Lyte's Elementary English. See that good language is used by pupils at all times.

Geography.

Natural Elementary. Use globe. Make a compass. Our pupils all face north, which will be a great help in studying the map.

FIFTH YEAR.**Reading.**

Baldwin's Fifth Year. Teach breathing as well as pronunciation. Clear, distinct voice. Accent, emphasis, pitch, force, rate, etc. Review diacritical marks.

Spelling.

Patterson's Word Book. See 4th year.

Writing.

Give close attention to position and movement. Do not accept anything but neat work.

Arithmetic.

Milne's Elements and Dubb's Mental. Use much time in teaching of fractions. Have objects before pupils.

Language.

Lyte's Elements of Grammar. See that pupils can not only give parts of speech, but that they can use them.

Geography.

Natural Elementary. Notice pages 143, 144. Draw maps. Where possible touch on historical subjects.

SIXTH YEAR.**Reading.**

Baldwin's Sixth Year. Follow directions given before. The average reader falls far short of the author's meaning, to say nothing of his feelings. Question in every way on the lesson.

Spelling.

Patterson's Word Book. Have words used in sentences as before.

Writing.

Watch movement. Neat work.

Arithmetic.

Milne's Elements and Dubb's Mental. Teach tables carefully and see that pupils know of what they are talking. Use mental work if possible corresponding with written lessons.

Language.

Lyte's Elements of Grammar. Attention may be called in a kindly way to errors. Teach use of dictionary.

Geography.

Natural Elementary. Draw maps. Teach areas by comparison. Teach productions by belts.

Reading.

Baldwin's Seventh Year. Follow instructions of other grades.

Spelling.

Patterson's Word Book. As previous year.

Writing.

Teach movement. Quickness is to be desired.

Arithmetic.

Milne's Standard and Dubb's Mental. Take nothing of pupil's knowledge for granted. Test upon all subjects.

Language.

Lyte's Elements of Grammar. Notice carefully the reviews called for in the book.

Geography.

Natural Advanced. Use the globe. We have one in reserve. Let us wear this one out by use. Use books of reference. Draw maps. Use the pronouncing vocabulary.

History.

Eggleston's Primary. Have the pupils bring in additional facts besides those found in the book. Dwell upon the characters mentioned in this work.

EIGHTH YEAR.**Reading.**

Baldwin's Eighth Year. The greatest difficulty experienced by the average high school student is that he is not able to read. He can pronounce fairly well the words in the book before him, and perhaps even deliver the writing of another, after the manner of an alleged elocutionist, but, for all that he cannot read. To read, one must think. He must think what another thought and as he thought it. To do this, one must, first of all, understand the general and particular meanings of words. He must understand the combinations formed

when words are put together in sentences. Unless he so understands words and their use, he certainly cannot expect to catch the meaning and spirit of another who speaks to him from only the printed page.

Pupils should be able to read before they reach this grade.

However, if pupils in this grade have not mastered even the mechanical part of reading which belongs to a much earlier period, spend some time upon this elementary work.

If pupils are lacking in their knowledge of common words, spend much time on this.

Test constantly by all methods known to the teaching profession to see whether pupils follow the thought.

See that pupils are able to read all text books used in this grade. Read and observe what has been outlined in all previous grades. Attention should be given to silent reading.

Read supplementary texts and literature provided.

Aim to direct the home reading of pupils, (1) by ascertaining what they are reading, (2) by suggesting indirectly or directly, books that are worth reading.

Spelling.

Patterson's Word Book. Thoroughly review the book.

Writing.

Follow directions of previous grades.

Arithmetic.

Milne's Standard and Dubb's Mental. See previous grades.

Geography.

Natural Advanced. Draw maps of Ohio and Trumbull county. Study history of both.

History.

McMaster's History of the United States to the Struggle for Commercial Independence, pages 1-205.

In all teaching of history remember that cause and effect are inseparably joined together. If you teach history as a series of disconnected happenings it will mean but little, and what is taught will soon be forgotten.

Trace every effect back to its producing cause, and history is found to be a study that appeals to reason as well as to memory. It will then be interesting, and "That which interests is remembered."

Study in detail those historic characters who, by reason of a strong personality, or force of character, rise above the general level of mankind.

Physiology.

Overton's Intermediate. Dwell carefully upon the practical use of physiology.

SPECIAL COURSES OF STUDY.

ORAL GEOGRAPHY FOR THIRD YEAR PUPILS.

1—Directions, compass, north, south, east, west; right, left, front, back, up, down, on, over, under, in, to, towards.

2—Slate map of table-top, desk, room. Blackboard map of same. Locate objects on map and have pupils get familiar with directions.

3—Develop terms, long, wide, thick, high, broad, narrow. Get idea of distance in inches, of foot, yard, mile.

4—Bound school rooms, school yards, etc.

5—Map of township, county.

6—Water, still, running; why running? boats, waterfall (why so called?). Tell of Niagara, Sault Ste. Marie, etc. Develop spring, brook, creek.

7—Islands, peninsulas, capes, isthmus. Have children find all these in nature.

8—Soil; sand, clay, gravel; fertile or barren. Rocks, slate, sandstone, marble (coal?).

9—Trees; apple, cherry, hickory, chestnut, walnut, buckeye, maple, oak, etc. Leaves; fruits; apples, cherry, nuts, cocoa, etc.

10—Study an apple; how are seeds arranged? etc.; plum, orange, lemon; compare them.

11—Grain in this locality; wheat, oats, rye, corn, use? Rice, etc.

12—Vegetables; potatoes, tomatoes, cabbage, peanuts. What things are conducive to growth? Sun, light, rain, snow, clouds.

13—Liquids; water, juices, molasses (sugar), coffee, tea, poisons.

14—Plants for clothing; flax, cotton, hemp; silk worm.

15—Animals; domestic, wild, birds, reptiles, insects.

16—Occupations.

17—Races of men.

18—The earth a sphere.

19—Motions of earth, time, seasons, clocks.

20—State, officers, government, laws.

PHYSIOLOGY.**Assignment of Work for the Primary and Grammar Grades upon the Subjects of Physiology, Hygiene, and the Effects of Narcotics.**

In compliance with the State law the effects of alcohol and narcotics are to be taught in all schools.

First Year. D Primary.

Laws of Health.—Talks on cleanliness, hands, face, person, hair combed. Teacher sees that these things are observed by all pupils, and that it does not end in "talks."

Necessity of sufficient and proper clothing. Wet feet and damp clothing. Playing out doors on wet days. Draughts. How to eat. Food for children. Good food—bread, milk, vegetables. Not good—strong foods—rich or greasy meats and gravies, candies, strong coffee and tea. Poisonous—alcoholic drinks, tobacco.

Importance of much sleep. "Early to bed," etc. Body, relation and name of parts; hands, right, left; fingers. Head, face, neck, trunk, legs, feet, toes.

Compare parts of human body with those of animals.

Use of each part. Wonderfulness of body. "The House I Live In."

Second Year. C Primary.

Review work of first grade.

Bones.—Framework of body. Why necessary. How bones are joined. Three kinds of joints—hinge, ball and socket, and compound.

Scholars bring some sample pieces of clean bone. Why hard and firm. (Mineral and animal matter.) Result if both ingredients are not there.

Bones of children; of adults. How bones grow. How bones may be misshaped—evil of.

Erect position. Why important. No need of stoop-shoulders, "As the twig is bent, the tree's inclined."

Seats in room must allow feet of all pupils to rest upon the floor. Why? If school furniture is not now so adjusted, give no rest to superintendent and board of education until it is.

Importance of exercise. Narcotics stunt growth.

Third Year. B Primary.

Review work of first and second grades.

Muscles.—(Flesh), the covering of the bones; color, red. Teacher bring before the class a piece of raw, red meat (beef). This muscle of the beef is similar to ours.

Pick to pieces a piece of boiled beef, thereby showing bundles of fibers. Compare to cables of suspension bridge. Characteristic properties of muscular tissue, contractility. Explain as a piece of rubber (elastic) stretches out, so a muscle "draws ups." Illustrate with biceps.

Arrangement of muscles in pairs. Why? All movements by contraction of some muscles.

Muscles do not extend to fingers and toes. Why? What takes their place? Use of tendons and chords, extension of muscles. Appearance of tendons, strength. Take leg of chicken to class, and show the use of tendon in leg. Take out tendon. Experiment as to amount it will lift in pounds. Compare this tendon with the branching tendons of our wrist, hand and fingers. How muscles grow strong.

Need of exercise—not exercise to the exhaustion point. Arm of blacksmith. Each pupil examine muscles of arm.

Flesh we eat, name: Ox, beef; calf, veal; sheep, mutton; deer, venison; fowl, fish, etc.

Fourth Year. A Primary.

Review work of previous grades.

The Skin.—Covering of muscles; appearance, color, smoothness. Cutis and cuticle.

Skin in commerce. Leather in shoes. Skin of what animal? Shoe strings, pocket books, drum heads, gloves, etc.

Use of our skin; to beautify, to protect, to regulate temperature, to remove waste matter. Organ of touch. Pores, use. If pores were closed, what? Do animals sweat? Horse? Dog? Outer skin insensible.

Sense of touch—one of the five. We tell much by feeling objects—hard; soft, shape. The eye alone, from one position, could not tell a sphere from a circle, a cylinder from a plane surface. Without touch the eye would be very imperfect. Blind child restored to sight could not by sight tell cat from dog although he had played with both all his life. Touch with the blind.

How care for the skin? Cleanliness, bathing. Why? Void draughts. Skin readily absorbs both food and poison. Danger of cosmetics. Narcotics.

Fifth Year. D Grammar.

Review work of previous grades.

Amplify work of second year on bones. Use chart. Uses of bones in commerce.

Digestion.—Use of lips, tongue, teeth, mouth. Teeth, arrangement as to incisors and molars; advantages of both kinds.

Lay much stress upon care of teeth.

Chew food thoroughly. Why?

Passage to stomach. Use chart.

Stomach, where? Size? Shape when full? Empty? Work of stomach. Eat at regular periods, not between meals. Stomach needs rest.

What to eat (see any good physiology). Food now read to enter blood. Experiments with alcohol. Is alcohol a food? Does it give strength? What drinks contain alcohol? Effects of alcohol upon the stomach. Use chart. Why are such drinks destructive to the physical, intellectual and moral nature?

Practical talks on how to prepare food for the table. Do not go upon the supposition that children learn this in every home. They do not. Plain talk on kitchen economics.

Sixth Year. C Grammar.

Review work of previous grades to whatever extent necessary.

Amplify work of third year on muscles. Use chart.

Circulation.—Organs; heart, arteries, capillaries, veins. Use chart. Heart, what? work, chambers, draw on board. Dissect heart of beef. Care of heart, free from excitement, violent exercise, too long rope-skipping. Tobacco. Blood. How much blood in average human body? (18 lbs.) What is the pulse? Where felt? What does it indicate? Number of pulsations per minute. Children count pulse sitting, standing. What is a blush? Account for the perpetual "blush" on the nose and face of the intemperate.

What effect has alcohol upon the temperature of the body (Lowers it. Men may deny this, but it is a fact. The thermometer shows it.) Effect upon the circulation. What is the normal temperature of the body? How ascertained? Read "The Fetal Board."

Respiration.—What is it? Universality, plants, animals, of both land and sea.

Organs, (a) air passages—nasal openings, larynx, trachea, (wind-pipe), bronchial tubes. Use chart. (b) Lung—Bring a lobe of the lungs of a beef to class. (c) Diaphragm—talks on structure, use and care of various parts. How to breathe. Give school breathing exercises. How to use the voice.

Purposes of respiration—to warm, to purify. How? Importance of pure air in school room, at home, in sleeping rooms, churches, etc. What is air? Experiments with air pump. Composition of air. Oxygen. Experiments with oxygen gas. Universality of this element in nature. Experiments with carbonic acid gas and lime water.

What does it show? Effects of alcohol upon the lungs. Read "The Worm of the Still."

Seventh Year. B Grammar.

Review work of previous grades to whatever extent advisable.

Nervous System and Special Senses.—(Touch, taste, smell, sight, hearing.) Brain, where? How protected? Size. Structure. Medulla oblongata, spinal cord, nerves, appearance of nerves. Mysteries and peculiarities of the brain as the seat of intellect. Practical uses of reflex action.

Use and abuse of nervous system. What weakens? What strengthens? Effects of alcohol and tobacco (especially the cigarette). Why narcotics are worse for the young. Ounce of prevention worth more than a pound of cure. Right formation better than reformation. "Acts form habits, habits form character, character form immortal destiny."

What gives us touch, taste, smell? Value of same to us. Special cultivation and peculiarities of.

Sight, eye, structure. Study chart. Lay much stress upon care of eyes. Dissect eye of beef. Light should come from left and rear in school. Light surface (glass in windows) in school room should be to floor surface as one to five, at least not less than one to six. Have pupils find ratio in their school room.

Philosophy of hearing. Speed of air waves. Seek to develop self-control. Cultivate no hot-bed growth of virtues which will wither and die in the presence of temptation, or be contaminated when confronted by vice. We want stalwart manhood and womanhood.

Do not try to merely point, but to lead pupils to that purity and strength of life where improper sights and sounds "Will die upon the eye and ear, no inward answer gaining."

NATURE WORK FOR ELEMENTARY GRADES.

Following is the assignment of Nature Work for the Primary and Grammar Grades.

Introductory.

• The purpose of this course is three-fold: To cultivate the powers of observation in children and young people, to import useful information, to awaken a love of nature.

First Year. D Primary.

Observe all indications of returning spring in (1) melting ice, (2) warm sun, (3) coming of birds, (4) appearance of ground, (5) milder air.

All life locked up in the tree or below ground is now becoming visible (1) in tiny green sprouts, (2) blade of grass, (3) buds.

Bud-scales—What? Where? Why? Lining of bud-scales, soft, wooly, covering often sticky, wax, why? (Keep out snow, rain and cold.)

Watch unfolding of buds of maple, lilac, horse-chestnut.

Position of buds, terminal, lateral. Lateral buds—opposite or alternate. Opposite (pairs), as seen in lilac, maple, horse-chestnut. Alternate (single), as in elm, oak, hickory.

Second Year. C Primary.

Review work of first grade.

Leaf, parts (1) petiole, (2) blade. Petiole, short, long. Observe difference in petiole of maple, oak, elm. Blade, structure, ribs, veins, veinlets; use of each part. Sap, what? Its use. How reaches leaf.

Venation—netted-veined, parallel-veined. Netted-veined—feather-veined, radiate-veined (maple leaf). Parallel-veined—corn. Read "What the Leaf said." Give each pupil grain of corn. Observe each grain consists of two parts: embryo and albumen, so called. Use of each. Amplify.

Plant corn and beans in box in school rooms two weeks before plants are needed. Dig up a few grains before plant appears. Examine. Talks upon germination. Write upon blackboard dates when various seeds were planted, dates when young plants first appear, height of plant when one week old, two weeks.

Parts of the young plant.

Third Year. B Primary.

Review work of first and second grades.

Margins of leaves; crenate as in catnip, serrate (saw) as in cherry and apple, dentate (toothed) as in dandelion. Other margins not necessarily named.

Base of leaf. Apex; pointed, rounded.

Shape of leaf; lanceolate as in peach leaf, ovate as in plum cordate as in lilac and catnip. Others. Use of leaves on tree? Amount of leaf surface on a tree is very great. "The Washington Elm," at Cambridge—a tree of no extraordinary size—was some years estimated to produce a crop of seven millions of leaves, exposing a surface of 200,000 square feet, or about five acres of foliage. (Teacher

explain and tell school extent of five acres. Also how many school yards like yours you could make out of five acres.)

Fourth Year. A Primary.

Review work of previous grades.

The flower, parts; sepal, calyx, petal; corolla, stamens, pistil, perianth. Let pupils bring common flowers and find these parts until they are perfectly familiar with them.

Learn names and peculiarities of common flowers.

Read "An April Day."

Fifth Year. D Grammar.

Review work of previous grades.

Read "The Bluebell." Moral taught.

Roots; tap-roots, fibrous. Use to tree or plant. Edible roots (subterraneous stems), potato, turnip, etc. Amplify. How cultivate all such products as potatoes, beets, turnips, rutabagaes, etc. Encourage all children who have gardens at home to cultivate one plant or small spot for themselves. Observe changes day by day, and though the youthful agriculturist should fail as to products, it will be a successful failure.

Sap of many trees is useful to man: Hard maple gives us sugar; pine, turpentine; acacia, gum arabic; caout-chouc, India rubber. Use of the above articles.

Sixth Year. C Grammar.

Review work of previous grades to whatever extent advisable.

Study trees, value of, conditions of growth.

Read "Woodman Spare That Tree."

Learn by sight: Maple, oak, willow, walnut, chestnut, hickory, locust, elm, pine, horse-chestnut, sycamore, apple, cherry, plum, quince, peach. Peculiarities of size, shape; growth of the foregoing.

Learn by sight the following woods as they would come from the shop: Pine, oak, walnut, maple, poplar.

Lumbering as a business. Where? How conducted?

Seventh Year. B Grammar.

Review work of sixth year, any other found advisable.

Find out from what trees came all the wood in this school building, including furniture, rules, slate frames, etc.

What special use is made of each of the common woods?

Can you name all the trees on the play ground?

Eighth Year. A Grammar.

Review work of any previous grades, so far as found advisable.

Historic trees: Washington Elm, Charter Oak, etc.

Trees worshipped by Druids. Read up on the Druids. Celebrated trees of the present time: Giant trees of California; banyan, palms, cinchona (why so named)?

Read "Landing of the Pilgrims."

What kinds of trees were in the "dim wood" at Plymouth? Are they there yet?

NATURE WORK FOR ALL GRADES.

Fall Term—For all grades, with whatever modifications are necessary to suit the age and attainments of pupils.

Fruits—Note different covering of apple, peach, pear, plum, cherry. When ripe? Why have seeds? Which way do the seams in an apple point?

Various uses made of fruits.

Grains—Different appearance in field—rye, wheat, oats, buckwheat, corn. Order of ripening. Bottle samples for school. Note covering of grains. Use of grains. Follow processes from the sowing to the using.

Nuts—Chestnut, hickory-nut, walnut, butternut, etc. When gathered? Bring samples. Bring specimens in the bur or shuck, and with leaves attached (if obtainable). Study the covering and observe how nut lies within.

Compare covering of fruits, grains, nuts.

Note the gradual decadence of vegetation and signs of approaching winter. Temperature, atmosphere, position of sun. Birds, animals (including squirrel and caterpillar), man.

Note the beauty of the autumn leaves, colors.

Bring in leaves picked up on ground and tell the kind. Make collection. Use of fallen leaves.

Late flowers—chrysanthemum, etc.

Read "The Melancholy Days are Come."

Should these day be melancholy?

ALUMNI.

Class of '99, Supt. C. W. Harshman—Elsie M. Hayes, Bernice E. Waters.

Class of 1900, Supt. C. W. Harshman—Alice A. Chambers, L. Claire Cowden, Mary Belle Lane, M. Helen Pelton, C. Florence Shipman, Jennie I. Taylor, Sadie A. Webb, Bertha D. Wood.

TEXT BOOKS USED.

	Authors.	Retail Price.
Readers, Primer,	Baldwin,	\$0 26
Readers, First Year,	Baldwin,	21
Readers, Second Year,	Baldwin,	29
Readers, Third Year,	Baldwin,	33
Readers, Fourth Year,	Baldwin,	33
Readers, Fifth Year,	Baldwin,	33
Readers, Sixth Year,	Baldwin,	33
Readers, Seventh Year,	Baldwin,	38
Readers, Eighth Year,	Baldwin,	38
Speller, American Word Book,	Patterson,	21
Writing, Number 1,	Barnes,	6
Writing, Number 2,	Barnes,	6
Writing, Number 3,	Barnes,	6
Writing, Number 4,	Barnes,	6
Writing, Number 5,	Barnes,	6
Writing, Number 6,	Barnes,	6
Arithmetic, Mental Complete,	Dubbs,	29
Arithmetic, Elements,	Milne,	26
Arithmetic, Standard,	Milne,	54
Algebra, High School,	Milne,	83
Geometry,	Milne,	1 04
Language, Elementary English,	Lyte,	29
Grammar, Elements,	Lyte,	42
Grammar, Advanced,	Lyte,	62
Geography, Natural Primary,	Redway & Hinman,	50
Geography, Natural Advanced, Ohio Ed.,	Redway & Hinman,	1 04
Geography, Physical,	Guyot,	1 32
History, First Book U. S.,	Eggleston,	50
History, U. S.,	McMaster,	83
History, General,	Colby,	1 26
Physiology, Intermediate,	Overton,	42
Physiology, Advanced,	Overton,	66
Natural Philosophy, Students Manual,	Cooley,	83
Botany,	Wood,	1 46
Civics,	McCleary,	83
Rhetoric,	Quackenbos,	83
Latin Grammar, Short,	Harkness,	66
Latin Reader,	Harkness,	73
Latin, Caesar,	Harper & Tolman,	99
Literature, American,	Watkins,	29
Literature, English,	Brookes,	29
Eclectic English Classics.		



THE ROAD MAKING MATERIALS OF PENNSYLVANIA.

THEIR LOCATION, DISTRIBUTION AND COMPARATIVE MERITS. ALSO SOME SUGGESTIONS FOR THE CONSTRUCTION, MAINTENANCE AND REPAIR OF ROAD SURFACES.

BY PROF. M. C. ILSENG, *State College, Pa.*

THE TOPOGRAPHIC DISTRICTS OF PENNSYLVANIA.

The map which is the frontispiece, will reveal the area and location of the three topographic districts of the State. The lines marking them following, as near as possible, the ridges of the mountains determining the boundaries of the several districts. The line which is drawn over the northeastern corner, irregularly across the State and sweeping down into the Ohio marks the southern boundary of the glacial moraine which is composed of rock waste, boulders, sand, clay, gravel, scratched blocks of native and foreign rocks of all kinds, averaging fifty feet in depth. North of this extreme edge, the ice had left on its retreat, similar material which extends upward through the State of New York and into Ohio. In many places this material obscures the local geology. The heavy black line which zigzags its way through the middle division and finally passes out of the State on the south, in Bedford and Fulton counties, lines the outcrop of the durable limestone which generally furnishes good material. Inside of the territory, bounded by it, are numerous rock waves, revealing all grades of material which are referred to in the alphabetic list of counties. The dark belt traversing Bucks to Adams counties is of red sandstone which furnishes the only sandstone of recognized reputation in the market for building purposes, but one which, though constituting poor road metal, contains numerous hills of volcanic rock extruded through planes of stratification of the sandstone. The darkened field along the border of New York comprises thin bedded, hard, flaggy sandstone of no value whatever for road purposes. The four counties almost exclusively covered by it are, therefore, totally devoid of serviceable material which is even tolerably good for roads. The other shaded belts on the map comprise

rock formations indicated by the table on the right hand. This map is printed from a reproduction of the colored map of the second geological survey.

On the opposite page is a reproduction of an illustration taken from the report of the Pennsylvania State College. It is a photograph of the large relief map of the State of Pennsylvania standing in the hall of the College, and exhibits with its light and shade some idea of the topography of the Commonwealth.

TOPOGRAPHY.

The State of Pennsylvania may be divided into three divisions, differing from one another in the character of the stone which is abundantly available for a top dressing to roads, and in the topographic features of the surface which determine the location, alignment, grade and permanency of the highways which are most feasible within their territories. Naturally, too, they differ in the comparative amounts of woodland and farming territory. The physiognomy of hill and ravine is determined by the nature and mode of occurrence of the rocks which immediately underlie the surface, and these depend upon the geological agencies which they have been subject. The road making materials of the State are the surface rocks, and within each of the three arbitrary districts are presented similar results of geological action, similar materials for the road master to employ and similar features for the highway engineer to combat.

The Allegheny mountains divide the State into two nearly equal parts—one field on the north and west, containing an almost level, unbroken bituminous region, and another on the south whose surface is corrugated with grouped strata that have been folded and crumpled into billows of great sandstone arches alternating with troughs of limestone or shale. The western field occupies about 55 per cent. of the area of the Commonwealth. This eastern half may again be divided into two districts by the high divide along the Kittatinny and Blue mountain range. (See topographical map.)

The western and northern district is a densely wooded territory whose average elevation approaches 2,000 feet above the sea in an elevated table land traversed by innumerable ravines and gorges. The banks are cliffed and terraced by durable sandstone caps roofing the softer beds of shale at intervals, in elevation furnishing exceedingly picturesque valleys.

The dip of the rocks is slight, scarcely perceptible in some places, except in the northeastern portion of the State. All the subterranean rocks for several miles in depth lie in position and order in

RELIEF MAP OF PENNSYLVANIA.
BY EDWARD B. HARDEN



which they were originally deposited on the oscillating bottom of pre-historic oceans. These sedimentary rocks have been undisturbed ever since. They have not suffered from any of the natural convulsions, but have slowly hardened under pressure without undergoing metamorphism or suffering any change that altered either their structure or their mass. Lying within the sphere of influence of the atmospheric agencies are only a succession of sandstone and shale, with a few isolated exposures of limestone over the entire area as a mantle, lies a loose mass of gravel and boulders which had been transported in earlier ages by glacial agencies from the north. The southern limit of this morainial matter is indicated on the map.

The middle district, which lies between the Allegheny mountains and the Kittatinny range, is composed of a belt of ridges and valleys about fifty miles wide, curving rapidly westward at the north and sweeping majestically around to a southward direction near the Maryland line. There are 2,700 square miles of stony linear mountain in its area. It is underlaid with a series of rock laid conformably one above the other, and, identical in sequence with those underlying the western district, at great depths. Originally they were laid horizontally contemporaneous with the coal measures of the western district, but at the time of what is known as the "Appalachian Revolution," they were compressed and folded into a series of rock waves forming parallel mountains of gigantic height whose western slope is a gentle one terminating with the Alleghenies, and whose eastern limit was marked by a vertical plunge to great depth. Floods, frost and heat have in a long process of time wasted the rocks until the mountains now existing, are but low cores and valleys through the softer rocks reveal a succession of limestone, sandstone and shale, neither the arches nor the basins are symmetrical "the lines of outcrop on the present surface revealing their shapes form a curious labyrinth of zigzags." The formations, therefore, in the processes of mountain making, have undergone a certain amount of metamorphism which have rendered the rocks more capable to resist the action of rains, floods, frost and heat than are those formations west of them which have not been subjected to the same pressure and heat.

The eastern district, which is more thickly populated than any other considerable section of the Commonwealth, is a gently undulating plain whose uniformity is broken only by a few clumps of the interrupted South mountain range and a few low ridges. Almost all of its entire area is cleared and cultivated. The formations essentially comprise the rocks forming the primary nucleus of the continent extending from Maine to Alabama. Granites and

gneisses cover the field with conformable layers of sandstone, limestone and shale, flanking them on the west and a belt of the very recently formed triassic sandstone, which furnishes a most excellent building material at the Kittatinny mountains. Traversing this belt along broken lines in many places are dikes of volcanic rock. Thus the eastern district presents to the builder and road master a great variety of massive as well as stratified rocks. Igneous, volcanic and sedimentary rocks occur in nearly equal proportions in the district, and are available as well as accessible for structural purposes.

THE TELFORD AND MACADAM TYPES OF ROADS.

It was in the beginning of the present century that Telford and MacAdam suggested methods of construction for roads after a long period of neglect, following the obsolete Roman methods of making pavement. And these typical road systems continue to the present day. The former engineer proposed to prepare a foundation bed covered with sand and broken rock, rolled and hammered into place and covered with large blocks of stone, closely fitted and laid, to furnish a regular surface arching transversely to the direction of the road. MacAdam proposed, instead of the top block pavement on the surface, a crushed stone layer which was compressed by traversing it repeatedly with heavy wheels or a roller of great weight until a smooth surface was formed. Roads built on these plans have, since the day of these engineers, been given the name of Telford or MacAdam, though they have degenerated somewhat from the original intent until now the latter term is applied promiscuously to any process of laying and rolling broken stone upon any roadbed.

MacAdam discovered the fact that almost any stone when broken into fragments would, with intimate contact and moisture, in a short time consolidate under the pressure of travel, and if freshly powdered rocks were added to the broken stone they would cement and set into a firm mass. The lapse of time has demonstrated this. It has been found since, that any broken material which has been firmly compacted and exposed to the natural elements will, under the beating of horses hoofs and the rolling of wheels, form a dust which, if not washed away, will penetrate with the rain into the interior of the mass, and upon drying become deposited to form a bond between the fragments of stone. If, too, the bits of broken stone be of sufficient hardness to resist the tread of wheels, a hard, dense, waterproof covering results which can bear up the load of constant travel.

From the engineer's standpoint, however, it is also equally requisite that the foundation be prepared and the grade and drainage

carefully provided for. MacAdam's argument in the construction of a road was that nothing could make as good a road as the dry foundation earth, and that no matter what was over it, the ground after all is the road and must bear the weight of passing vehicles. The great object then to be sought in making a permanent roadway, is a dry earth foundation with a roof covering of stone of such compactness as will form an impervious coating, and of such a thickness as will carry the weight upon it.

The integrity of the Telford pavement, therefore, depends upon the rigidity of its foundation, and its integrity cannot be preserved unless the interstices are filled to prevent the percolation of water. Few varieties of rock can be employed on top. The pavement is far more expensive than the macadamized road; it wears down very rapidly, probably because it is drier and the large stones act as an anvil under the hammer of the passing wheels to crush the underlying stone.

In the MacAdam road it is the superstructure which must receive consideration, and to obtain the cemented waterproof covering, the material must be properly selected and the surface rolled. It may be of any rock which will cement and is hard. It wears smoothly and uniformly except in places where the bond between the crushed material is broken at the time that frost comes out of the ground and continued heavy hauling cuts deep ruts along given lines. It requires little repair except to darn the few soft spots. The Telford, on the other hand, needs a complete resurfacing if worn through.

The Telford road or a MacAdam road with Telford foundation costs about \$800 for each foot of width per mile of length.

The Telford surface of roads may be obtained by a variety of materials, though there is no material which can be said to possess all the desired requisites for a perfect pavement. Nevertheless, there are several classes of paving materials divided according to their character and the intensity of traffic which they are capable of bearing. That a smooth surface is the first requisite, is undoubtedly true, and a hardness of the material without wearing to a slippery surface is indispensable. In addition, the interstices between the blocks must be filled with some impervious substance to protect the foundation. The construction is usually of sand, gravel or crushed stone base, spread over a rolled foundation and a concrete of stone covering into which the dressed blocks of stone are rammed. Granite, sandstone and trap rock are employed for the latter purpose. If we broaden the term Telford, it may also include pavements of vitrified brick imbedded in a similar foundation, to that of natural stone. Philadelphia has granite, brick, rubble and cobble pavements, also slag-block—590 miles in all.

The pavements adopted and established for all streets and roads should be uniform. The following pavements are recommended: For streets having a heavy traffic, the dressed granite and Medina sandstone blocks are best suited; for streets other than those in the immediate business section, macadamized is to be preferred. Gravel roads are hardly recommended where the amount of travel is heavy unless they have been constructed under engineering advice. Vitrified brick pavements are meeting with favor in towns of considerable size and may even be employed in a single track way in the rural districts where natural rocks for macadamizing are not available. The general type of Telford road is more expensive in construction than that of macadamizing, which is much cheaper than the brick pavement and more costly than a gravel surface. Except in densely populated localities where the dressed stone blocks can be had abundantly and where labor is very low, the cost of Telford pavement would be prohibitive in all regions.

THE FORCES WHICH TEND TO DESTROY ROAD SURFACES.

The agencies which are engaged in the destruction of rock exposed to their action, whether in quarry face or on roadbed, include excessive rains, changes of temperature, frosts and winds. These forces are chemical and physical in their action, and in addition to them, the surfaces of roads are subjected to dynamic forces of travel, the beating of horses hoofs, the grinding produced by sliding wheels and the crushing produced by heavy weights. These forces result in abrasion of the surface, the formation of dust and the loosening of the particles of stone. The material which may be used for road surface, with different degrees of resistance to these forces are affected by them to varying degrees. Some of them are more readily affected by the dynamic forces of travel than by the natural agencies, though all are to a greater or less degree softened and destroyed by the natural agencies which everywhere prevail. Pennsylvania is particularly characterized by those climatic features which impair the conditions of carriage roads.

The Effect of Rain. In this State the average precipitation is about $10\frac{1}{2}$ inches in the winter and in spring, and 29 more in the fall and in summer. These waters invariably contain solvent acids. Rain is often a dilute acid solution. As such it removes some of the soluble portion of the stone with which it comes in contact. If the rainfall is not immediately carried away from the surface, it tends to soften the rock, penetrate into the interior, percolate to the foundation and there destroy the bearing for the ballast. A basin is produced by the sinking of the ballast and opportunity is

offered for the formation of pools which further increase the damage. Though it has been stated above that any stone may be employed for top dressing of roads, nevertheless it will be understood that those which are soluble or possess soluble constituents must be inferior in quality. So, too, those which are porous or loosely coherent will have their integrity destroyed, besides admitting of the infiltration of a large amount of water to the natural foundation. A wet day, therefore, is the test of a road dressing material. The relative ability of the several rocks to resist this effect of water is discussed under the several varieties of road making materials, pages 568-572.

Frost. An admission of water into the interior of the surface covering is another effect still more destructive in regions which are subject to intense cold. The frost is a potent factor in rock weathering, and stones, which are porous or become permeable to water by solution of their soluble constituents, are rapidly weakened and crumble by the freezing of the contained water; and such materials are utterly worthless for roads, if there is no cementing material in the incoherent rock to rebind the particles after thawing, or if artificial cement has not been added. This weathering agency in our climate demands the concentrated effort of the engineer's skill to overcome, for its influence is pernicious and all stone are subject to its attack. Compared with it the other difficulties of the engineer are comparatively trivial.

It is evident, therefore, that great care must be exercised to convey the waters as promptly as possible by providing the road with side gutters, and, if necessary on low ground, sub-drains. In Massachusetts where these essentials are observed no serious damage seems to have been done by floods and freshets. The expenditure in Massachusetts for maintenance has been for cleaning gutters and shoulders and placing on binding material upon the roads traveled by light wagons, and where the binder has been removed by the wind faster than the wear of the stone supplies it.

The effects of changes of temperature upon the rock are not so serious, though the result is to expand and contract the mass, open crevices through which water may penetrate to the foundation and materially lessen the strength of the rock by loosening the constituent minerals.

The wind has an action upon a road of any description that is not inconsiderable. It removes the dust produced by travel which accumulates on the surface. It thus carries away not only the cushion which furnishes a relief to the traveler, but also the cementing material for the broken bits constituting the macadam. This wearing action, though less conspicuous than that caused by rain,

is as persistent and even as great in amount. Soft stones, such as limestone, incoherent loose shale and crystalline granites are the sufferers from this cause and, therefore, undesirable for the top dressing to high grade roads. This film of dust can, however, be retained by constant sprinkling.

The weathering which results from water and wind action is, therefore, more pronounced upon porous stones like sandstone, those which are soluble, as limestone, those which are soft, like shale, and those which contain foliated mica, like gneisses and granites. These are undesirable for a hard road floor such as is required for heavy traffic. The road ballast must be impervious to water, its binding material preserved and its foundation kept dry by such means as the road master can employ. Upon this point engineers differ only as to the means which is best capable of attaining this end.

THE CURSE OF THE NARROW TIRE.

The enemy to the integrity of the roadbed which is as destructive as any of the natural forces, but which is easily remediable, is the narrow tire. Naturally the effect of a rotating disk is to cut through and to shear aside the individual fragments in the covering, and, if the pressure is excessive, to produce a large amount of dust, and at the same time cut into the road covering like a knife. Ruts and dust are the consequent result. It has been shown from various sources that the pressure produced upon the area of contact on the road by a narrow tire amounts to more than 250 pounds per square inch and may reach a pressure of 1,120 pounds per inch of run. This is often greater than the pressure of the heaviest rollers which are engaged in constructing smooth roads, and no matter how carefully the macadamized surface may be built, a narrow tired, sometimes knife-edged, wheel is destructive. It has further been shown that only on a soft, sloppy and muddy surface, overlying a hard roadbed, does the narrow tire show to any advantage in the matter of economy of power as compared with a broad tired wheel. This condition lasts for but a very short season in spring, when the soft covering of the road will consist of sticky clay, immediately after a storm. Then the narrow tired wagon pulls more easily than the broad tire. These periods are also the seasons when little freighting is done.

A great variety of tests have been made to establish the claims of wide tire over narrow tired wheels. The most exhaustive and reliable series ever yet made in America, so far as the author is aware, were conducted by Professor C. M. Conner, of the Agricultural Experiment Station of Missouri. (Bulletin Number 39.)

In Bulletin Number 12 of the United States Department of Agriculture, Office of Road Inquiry, are also given tables and results of tests.

It has been shown that on a macadamized street the same power drew 2,518 pounds on the wide tired wheels as was necessary for 2,000 pounds on narrow tires. On gravel road 2,482 pounds could be hauled with the same draft required for 2,000 pounds on narrow tires. And on broad tires the power which could haul 2,530 pounds on a dry, hard, smooth dirt road only drew 2,000 pounds on the common width of tires. The maximum weight that should be allowed per inch of width of tire should be 550 pounds.* The width of tire should be increased proportionately with the increase in the weight of the load. It must be understood that the width of tires does not affect the traction on hard roads, only the condition of their surface and cost of maintenance.

Width of tire of 2 inches allowed load, including weight of wagon, 4,400 pounds.

2½	4,850
2¾	5,500
3	6,050
3½	6,600
3¾	7,150
4	7,700
4¼	8,250
4½	8,800
5	9,350
5½	11,000
6	12,200

For vehicles with suitable springs, the allowed load could probably be increased one-third.

One objection offered against the introduction of wide tires is the disadvantage at which it is supposed to be placed when required to run over the deep ruts made by a narrow tire, after the walls of these ruts have become rigid and the surface of the road worn comparatively smooth elsewhere. When only a very few individuals use broad tires the difference in pull is slight. But even one run of a broad tire will compress the covering sufficiently to materially decrease the draft of the vehicles passing along thereafter. Apparently "the ruts made by narrow tires are not the serious obstacles to the adoption of the broad tires that they have been believed to be." Be that as it may, certain it is that for the purpose of the road master every run of a narrow tire is an injury, and every run of a wide tire beneficial to the road. Again it may be suggested that if the fore and hind wheels be set on different gauges, a still further benefit would ensue to travelers and road and they would become preservers not destroyers. A six inch tire is recommended as the most satisfactory width for farm wagons or road travel.

*N. Y. State Engineer.

The destruction which ensues to the surface by the use of the narrow tire and the fact that a larger load can be drawn by the same power on a broad tire than on a narrow tire wagon, ought to convert the farmer in favor of the former, especially as its cost is not much, if any more.

THE ROAD MAKING ROCKS.

Rock Formations. The rocks must be capable of withstanding the atmospheric agencies and dynamic forces which operate upon the surface of a road and must, therefore, possess such inherent characteristics as will give the desired durability. The State is supplied with a variety of such material though they are of varied composition and texture. Classed into the three groups of sedimentary, igneous and volcanic, with different origins and of different constitutions, they occur in separate fields of the State. The middle and western topographic districts are entirely underlaid with sedimentary rocks; so also the western portion of the eastern district contains sedimentary formations. Those of the western topographic district have undergone no change since they arose from the sea and though of the same general composition as those in the middle district, are more loosely compacted than their equivalents which have been compressed in the process of folding the ridges between the Allegheny and North Mountains. Those which are in the eastern district have been subjected by natural convulsions; while the plutonic and volcanic rocks of the extreme southeastern portion of the State have undergone further change and have been subjected to the forces involved in the upheavals of recent time.

The Volcanic and Plutonic Rocks. The plutonic rocks are the oldest rocks in the State and by reason of the metamorphism which they have endured are recomposed in crystalline form. The volcanic rocks of the eastern district are more recent than almost all of the sedimentary rocks, and of course, than the plutonic rocks, and are certainly younger than the brown sandstones among which they are found, having been extruded from below in a more or less molten condition and rapidly cooled on the surface. The volcanic rocks are of a structure and composition much like the old igneous rocks. Both are more or less crystalline and complex. They occur in deposits which are massive. The distinction between the plutonic and volcanic rock is a scientific one, due to a difference in the manner and condition of cooling from a molten state. The members of the series of massive rocks which should surely be designated as plutonic, are granite and gneiss. At the other end of the series, which comprises those rocks distinctly volcanic, we

have lava and gabbro. Neither of the latter are glassy like the fluid or volcanic slags, but are basic and semi-crystalline. They may readily be distinguished in their physical appearances from the true granite. The plutonic rocks are coarse crystalline. The volcanic are fine grained. Their molecular arrangement was interrupted. Between these extremes are a variety of composite minerals resembling both of the extreme types, but differing from them slightly only in preponderance of one or other mineral. The later geologists are abandoning the distinction between the two groups because of the difficulty of drawing the line of demarcation between them. In any event these massive rocks are superior to the sedimentary rocks for road surfacing, and on pages 572 to 575 are given a few simple tests by which the road builder may distinguish between the different varieties of available stone.

The sedimentary rocks include the limestone, sandstone and shale in considerable range of composition, merging one into the other until it is a difficult matter sometimes to determine whether a certain stone shall be regarded as calcareous sandstone or a silicious limestone. These rocks are composed essentially of but one mineral and occur in layers, definite in thickness, easily followed with the exercise of a little care, and, though they may change somewhat in composition from one end to the other, maintain the same characteristics throughout. On the map on the frontispiece will be found lines indicating certain formations. These represent the places at which the formation appears on the surface. A given line, therefore, such as the heavy zigzag one, indicates the outcrop of a continuous formation which the geologists have called Helderberg. Above it and below it are other layers of sedimentary rock which lie in a given order and are conformable with it. Each may be traced in location by following parallel to the dark blue line wherever it may go. More extended maps, colored for each separate formation of rock, may be found in the county reports of the Second Geological Survey.

Road Stone. These rocks, sedimentary and massive, constitute the State's road making materials and are to be looked for only within the areas covered by the formations to which they are confined or where they have been carried by streams into adjacent areas. Broadly speaking, it may be said that the volcanic rocks are of the highest grade, and, with the plutonic rocks, are superior to the sedimentary rocks for the top dressing of roads. The road builder, therefore, has a choice of materials restricted to the group of substances accessible within his district, unless the exigencies of the occasion demand a quality of material superior to that which his township affords; in which case he will select the superior rock

for importation. Within his given district, however, there is so great a difference in the value of the stones composing the several layers, that he may find certain formations containing better limestone than are in the layers which have hitherto been employed. He may even find that some sandstones of his district may be applied upon the roadbed with better results than some of the argillaceous limestones which are immediately nearby. The properties which the several rocks have and the elements which they contain, tending to a high degree of durability, should be examined as well as the texture of the rock which would determine its ability to resist the weather.

The value of a rock for the roadbed depends upon its strength and durability, and in so much as it is impossible to prevent the action of the ordinary processes which tend to gradually destroy the surface, we must materially minimize their effect by suitable material and construction. A knowledge of the chemical composition, constitution and texture of the several rocks which are available furnishes a good clue as to their relative merits. But we cannot entirely depend upon a physical inspection of the rock, but must make such tests as will confirm the physical examination. This test may be either the examination of the formation in the field or mechanical tests in the laboratory unless we have experience to guide us.

Superficial Examination. It is the weathering qualities of the stone and the reliability of its constituents with which we are concerned and this can be learned by a careful observation of the natural exposure at old quarry faces. Here the experienced observer may gain some idea of the wear, perhaps better than can be had from the ordinary tests hastily made in the laboratory, for the former represents the protracted tests of nature. Either of these methods lack definiteness and the results of one can be expected only in conjunction with those of the other. The unweathered stones might be compared with a natural exposure of the same formation in the field, but the degree of its durability cannot be entirely gauged by its appearances in the outcrop because of our insufficient knowledge of the length of such exposure.

The laboratory test, which is necessarily brief, must be severe and exaggerated if it is to furnish a guide in any wise approximating with that of the prolonged test of nature. These tests have only recently been entered upon. The knowledge which is at hand is meagre though facts have been collected from abroad and in America in sufficient numbers to afford ample information for the present stage of road construction.

Experimental Roads. Several States have established experimental

roads to illustrate the need of construction and the value of the material employed for top dressing. Each State and district is easily supplied with a large variety of available materials, so that to be comprehensive, the tests must comprise a large number of measurements, at different parts of various roads, prolonged over a considerable period of time, if the results are to have definite value. The endurance of the several varieties of stone subjected to travel may then be observed and the comparative merits ascertained. France made a series of tests beginning in 1865 and repeated at intervals until 1893, in which year the measurements amounted to more than one-half million in number. They were compacted to determine the variety of the various materials of construction employed on the short sections of the road along the same line of travel. The record of traffic was made every thirteenth day of the year and the observations were extended over 22,000 miles of road. The traffic was classified and rated as follows:

1. Each horse hauling a public vehicle or cart loaded with produce or merchandise, 1.
2. Each horse hauling an empty cart or a private carriage, 1-2.
3. Each horse, cow or ox unharnessed, and each saddle-horse, 1-5.
4. Each small animal (sheep or goat), 1-30.

The results of this test have been confirmed by those in America, and information in this direction may be had from the office of Road Inquiry of the United States Department of Agriculture, which is so ably administered by General Roy Stone. The results obtained in Saint Louis a few years ago are quoted below:

"Sections of road were built of the different materials, 22 inches wide and 8 feet long. Two wheels, with tires $2\frac{1}{2}$ inches wide and loaded to 2 tons or 800 pounds per inch width of tire, were made to pass back and forth over these sections by machinery. The heaviest traffic at that time in St. Louis was 75 tons per day per foot of width, and the average for business streets was 35 tons. Estimating the effect of horses' shoes at one-third of this amount, 50 tons per foot was taken as a standard. The samples were weighed before and after testing, and were subjected to an amount of wear by the wheels estimated to be equal to eight and a half years on the street.

"The total abrasion of the fire brick pavement was 9 per cent., or a depth of $\frac{3}{4}$ of an inch, but about one-half of the brick were broken. Asphaltum blocks under the same test wore 14 per cent., and but one was broken. Broken stone lost 1 per cent. under a traffic of 12.7 tons per foot of width. Broken stone and sand lost 1 per cent. under 16 tons per foot. Limestone block lost 1 per

cent. under 4,400 daily tons per foot of width. Wood blocks lost 1 per cent. under 12,900 daily tons per foot, and the granite blocks lost 1 per cent. under 70,000 tons."

Laboratory Tests.—A durable covering may safely be expected from a material which shows its ability to withstand the elements and which behaves well under laboratory tests. As there is no absolute standard measure, however, the engineers have gradually adopted a set of ratios expressing the amount of wear which a rock undergoes when subjected to a given amount of force under given conditions for a stated length of time. These conditions are, of course, arbitrary, but if samples of stones intended to be used for road coverings are subjected to the same series of tests under the same conditions, their comparative merits may be ascertained from the results, not only among one another but also with those of similar tests made elsewhere by other engineers. The stones are, therefore, arranged in order of merit according to their ability to show the same satisfactory results under these conditions in the laboratory. We will herewith describe briefly the tests which has thus been standardized.

DESCRIPTION OF TESTS OF ROAD BUILDING MATERIALS.

Recalling that the qualities of a high-grade road-building material include strength, hardness, resistance to abrasion and a power of re-cementation, one will recognize that these properties must be tested by laboratory means similar to the natural agents. 1. The strength of the stone is ascertained by subjecting it to pressure, and the amount of such pressure is ascertained, from which may be determined the number of pounds of pressure which a square inch of area of the rock will support. 2. The ability to resist abrasion of grinding wheels and horses' hoofs is ascertained by grinding the surface of a weighed amount of broken stone against one another, and weighing the amount of dust produced in a given time. This will show the amount of dust obtained from one pound of the rock. 3. The strength of the binding material in the broken stone is ascertained by moulding the dust produced in the above test for abrasion and subjecting the bricks to crushing test from which may be ascertained the amount of weight which the cement is capable of supporting by rupture.

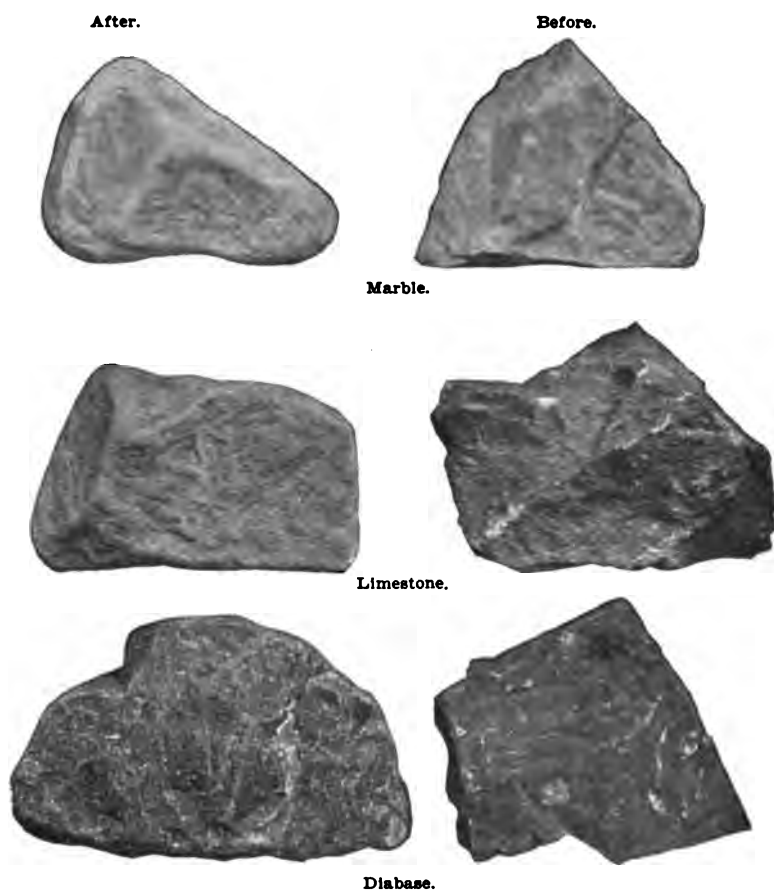
There are tests for ascertaining the comparative merits of the road ballast; 1. To determine the amount of water which a given bulk of stone will absorb, to ascertain its porosity; 2. To determine the result of subjecting the saturated stone to an intense cold, by which its resistance to frost may be known; 3. The chemical analysis for determining the composition of the rocks in terms of the elements

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Fig. 1.



Views of rock fragments before and after the abrasion tests.
By courtesy of Maryland Geological Survey.

composing it; 4. An examination by the compound microscope to see how the minerals of the rock are knit together and what is their condition as to weathering.

The Crushing Strength of the Stone. While the coherence of the particles is determined by their appearance under the microscope, the strength of the union is not known except by the crushing test. But it is hardly necessary to determine the exact crushing strength of a stone, for it is rare to find one which will not be able to support at least 6,000 pounds to the square inch. Many stones range as high as 25,000 pounds to the square inch. The heaviest pressure or the severest impact which is likely to fall on the road metal is far below the resistance of even the lowest grade of stone, and, as a consequence, the matter of the strength of the stone to be used for roads may well be left out of consideration in the discussion.

The test for abrasion, or the relative wearing powers of rocks, is made in a rattling machine, which consists of a number of cylinders, 8x13 inches, mounted diagonally on a rotating axle and turned at a rate of 30 revolutions to the minute. Into these machines a weighed amount of broken stone (about 5 kilograms, or 11 pounds), of a size less than two and one-half inches, is rolled for about five hours. At the end of that time the samples are carefully sifted, dusted and again weighed, the loss in weight being the dust formed in abrasion. From this weight is determined a *co-efficient of wear*, to indicate the relative quality of stone. Its value is found by dividing 400 by the amount of dust formed per kilogram of rock. That is, a rock producing 40 grams of dust to the kilogram will have a co-efficient of wear equal to 10. The more dust it produces, the greater will be the co-efficient to wear, the softer the stone. Generally speaking, the co-efficient is inversely proportional to the amount of dust formed in the test. The wear produced by this method is, of course, not precisely like that to which rock is subject on the road and does not measure the actual resistance of a rock to the dynamic agents, yet the test is valuable for comparative purposes. It assumes that the wear inflicted upon the specimens in rotation bears a definite ratio to that imposed by the traffic. The standard is taken at 20 grams because very few rocks furnish less than 20 grams per kilogram, that is, about 2 per cent. Illustrations opposite this page (Fig. 1) reveal the effects of the rattler test upon the hard diabase and the soft marble.

The National Brick Manufacturers' Association made the following recommendation for rattler tests of paving brick, which is the chief test and should be made without shot of any kind. The charge of brick should not occupy more than one-sixth of the volume of the chamber of the rattler; the rate of revolution should be not more than 30 per minute, and the result is to be taken from the average of two distinct tests after 1,800 revolutions in each.

The crushing action of blows and the resistance of the rock to it can be directly measured in a testing machine which imitates the natural force in its effect.*

The cementation test has at last been standardized after many years of experimentation. Its purpose is to obtain a knowledge of the relative binding power of the dust of various stones used in road making. Though it has long been recognized as the most important property possessed by a first-class road metal, a knowledge of the processes involved in re-cementation has been a matter of considerable speculation. They probably involve: (1) Adhesion between the dust particles produced by capillarity; (2) the binding property of fine material possessing a small quantity of clay; and (3) the induration resulting from the deposition of calcite or other substances when the road's surface becomes dry, which were held in solution in that zone of the road which serves as a roof to the sub-structure; (4) capillarity existing between the walls of adjoining rock.

All stones appear to possess to some degree binding properties, though those which are decayed, as for example, most field stones, have lost much of the power of cementation. Experience has proven that the binding power of all powdered rocks is usually sufficient to hold together the faces of stone when rolled into place. The best method of measuring the strength of the bond is the impact test.

The stone is reduced to dust, run through a 100-mesh sieve and moulded wet into a briquette one inch diameter and one inch high, by pressure of 1,400 pounds per wet inch. Usually it requires an ounce to make such a briquette. It is dried for two weeks in the ordinary temperature of a room. The briquette is subjected to the impact of a two-pound falling hammer, arranged like a pile driver, to drop through a stated height as many times as it is necessary to break the briquette. With each impact upon the briquette the weight rebounds until the fatal blow is struck. This breaks the bond of cementation. The number of blows is counted and is taken as representing the binding power of the stone and is so used to compare this property in road ballast. The greater the number of blows necessary to overcome the cohesive strength of the pulverized and cemented rock, the higher is its grade.

For making the registry complete during the test, the hammer works automatically and can be dropped any desired height upon a plunger under which the briquette to be tested is placed. The plunger is held in two guides and attached to it as a lever, pivoted at one-sixth of its length from the plunger and carrying a pencil at its free end. The pencil has a vertical parallel movement five times

* The Deval machine used by the National School of Roads and Bridges of France, described in Report of Massachusetts Highway Commission 1899; also in Geological Survey Maryland III.

as great as that of the plunger, and its movement is registered on a drum against which the pencil presses. The drum rotates through a small angle at each stroke of the hammer; thus, an automatic diagram is taken of the behavior of the briquette throughout the whole test. The point brought out by this machine is the fact that, when the hammer falls on the plunger, if the material beneath it can withstand the blow, the plunger recovers from the downward thrust given it by the hammer; if not, the plunger stops at the point to which it is driven. In this way the number of blows previous to the critical blow, which destroys the bond of cementation, are accurately recorded on the drum.

A chemical analysis would materially aid the engineer or road builder in determining the suitability of a given rock for his purposes, in so much as it is the exact method of ascertaining the elementary composition. But it gives no clue to the combinations of these elements as minerals. The chemical composition of many marbles is identical with that of some limestones, but their properties are totally different and their merit far from equal; so, too, granites and lavas do not resemble one another in texture, strength or durability, yet their chemical composition may be alike. For various reasons, chemical examination is superseded by the microscopic, the latter may even eventually render the performance of a physical test unnecessary. For, when intelligently interpreted, it exposes to view the construction of the rock.

CHEMICAL ANALYSES OF SOME ROCKS.

THE MAJORITY FROM SECOND GEOLOGICAL SURVEY OF PENNSYLVANIA.

Limestones.	Carbonate of lime.	Carbonate of magnesia.	Insoluble matter.	Ferric oxide.	Locality.
Armstrong county, Upper Freeport,	96.45	1.45	0.93	0.96	Logansport.
Armstrong county, Ferriferous,	95.50	0.90	2.03	1.31	Madison.
Centre county, Freeport,	42.90	22.70	18.73	.....	London Grove.
Chester county, Trenton,	54.10	43.30	1.96	0.61	Nippenose Valley.
Clinton county, Trenton,	95.07	1.04	2.66	0.26	Bellemonte.
Cumberland county, Trenton,	59.50	36.90	3.20	.....	Pine Grove.
Cumberland county, Trenton,	72.32	20.59	2.31	*4.43	Mt. Holly.
Cumberland county, Trenton,	86.36	5.34	8.41	0.57	New Athens.
Clarion county, Upper Freeport,	93.80	2.27	1.80	0.76	Reimersburg.
Clarion county, Lower Freeport,	82.00	6.31	7.90	2.73	Porter.
Clarion county, Ferriferous,	95.23	0.40	2.20	1.31	Glen Hope.
Clearfield county,	93.81	1.71	2.10	.....	Caledonia.
Elk county, Lower Freeport,	66.91	9.84	16.13	.....	Horton.
Elk county, Ferriferous,	57.32	8.85	21.25	7.94	.....
Franklin county,	51.38	21.31	2.18	0.91	Most Alto.
Franklin county, Ferriferous,	57.39	42.39	2.18	0.91	Williamstown.
Forest county, Tionesta,	40.64	1.17	0.98	0.26	Tionesta.
Forest county, Tionesta,	40.64	1.17	55.18	2.12	King of Prussia.
Jefferson county, above the Upper Freeport coal,	98.16	.....	0.77	10.70	Big Run.
Jefferson county, Upper Freeport,	77.14	4.68	11.78	3.79	Brockwayville.
Jefferson county, Ferriferous,	89.10	1.61	6.17	2.14	Jersey Shore.
Jefferson county, Helderburg,	94.39	1.70	1.91	1.31	Trexlerion.
Lycoming county,	70.59	1.74	21.68	4.68	Newport.
Lehigh county, Chemung,	48.60	40.40	9.24	.....	.....
Perry county,	60.21	1.66	31.62	5.38	.....
Somerset county, Ligonier,	53.74	.....	43.96	0.91	.....
Wayne county, Catskill,	64.39	1.81	23.80	4.16	.....
York county,	73.18	4.37	21.50	0.60	Dillsburg.
York county,	93.57	0.96	4.36	0.30	Seitzland.
York county, Mesozoic,	44.96	5.27	14.01	13.68	.....

*Alumina. †With alumina.

Sandstones.	Silica.	Ferric oxide.	Ferrous oxide.	Lime magnesia.	Alkalies.	Locality.
Dauphin county,	31.52	2.02	3.80	0.70	1.20	Hockersville.
Bucks county,	34.35	2.32	7.26	0.73	3.08	Morrsville.
Dauphin county,	34.00	1.98	.....	2.30	.....	Laurel Run.
Dauphin county, new red,	30.34	1.09	15.03	1.12	1.47	Hummelstown.
Bucks county,	33.34	1.07	4.35	0.95	1.50	Newtown.
Bucks county,	32.72	1.92	*10.29	0.27	3.90	Yardley.
Luzerne county,	30.36	.....	*3.35	2.00	.....	White Haven.
Shale.						
Wayne county, Catakill,	59.26	*19.08	*10.08	2.17	4.86	Goat Hill.
Peach Bottom slate,	58.37	*21.98	10.66	1.50	1.90	Morrsville.
Dolerite,	60.26	3.36	*21.93	6.63	5.61	Brownburg.
Dolerite,	53.83	6.46	122.00	14.28	3.33	Morrsville.
Diorite,	50.62	2.14	122.76	17.03	4.76	Vanardtsalen.
Pyroxenite,	46.88	3.08	124.11	16.50	4.25	Fallingdon.
Gneiss,	57.52	5.52	120.97	8.65	3.42	Morrsville.
Syenite gneiss,	57.52	5.52	120.97	8.65	3.42	Morrsville.
Gneiss,	56.42	0.21	118.94	0.21	14.32	Neshaminy Creek.
Chlorite schist,	46.35	1.43	125.44	20.92	0.53	Neshaminy Creek.
Slag.						
Armstrong county,	31.80	*12.53	0.63	50.76	.....	.....

*Alumina. †With alumina.

The petrographic examination of specimens is very important and constitutes the quickest, simplest method of classification. The unaided eye cannot clearly determine the composition of the rock, nor can even the expert mineralogist always determine the component minerals without auxiliary aid. Even if obtained, neither a chemical nor a mineralogic analysis will convey any information as to the internal arrangements of the component minerals.

The inspection of a mineral specimen by a lens would contribute some features which could not be observed by the eye. But a thin slice of the rock, cut, polished, mounted and examined by the microscope would clearly reveal the composition of the rock, its structure and the manner in which its several constituents are united. These properties the road master desires to know, and they can be quickly determined, easily prepared and at slight expense. By this aid the percentages of the several constituent minerals and the precise classification would be known. The writer believes this test is the most important of the series which should be applied effectively in the laboratory. It reveals also the causes for the differences in strength in the classes of road ballasts.

As will be seen from the accompanying illustrations, the volcanic rocks are made up of minerals very much intertwined, and this fact accounts, in a great measure, for the toughness of the rocks and the difficulty encountered in breaking them. In the granites and gneisses no such evidence is found, so they crumble more rapidly than the volcanic. Quartzite, which is made up of particles of quartz cemented but not intertwined, would then be more or less easily disrupted, according to the strength of the cement. The same, you will notice, is true of sandstone. Limestone will be seen, from the accompanying illustration, to be made up of particles of material of about the same shape as the crystallized cement which unites them. It is a compact rock and homogeneous because made up of small particles of fairly hard material, united by a cement practically as strong as the particles themselves. It, therefore, does not crumble though it is not necessarily strong.

These illustrations furnish a guide to the examination of rock with the compound microscope, and perhaps confirm to the reader the view advanced by the writer as to the value of the microscope for this purpose. It reveals the causes for the differences in strength; it shows the presence and amount of decomposition and condition always found in our rocks to a greater or less extent; it determines the character of the chemical changes, and may be said to give a partial elucidation of the factors on which the structural value of a stone depends. The sole objection to it is that it is not quantitative in its results, which depend largely upon the observer's accuracy. Compare the appearance of the massive rocks in Figs. 7, 8, and 9 with those of the sedimentary in Figs. 2 to 6 inclusive.

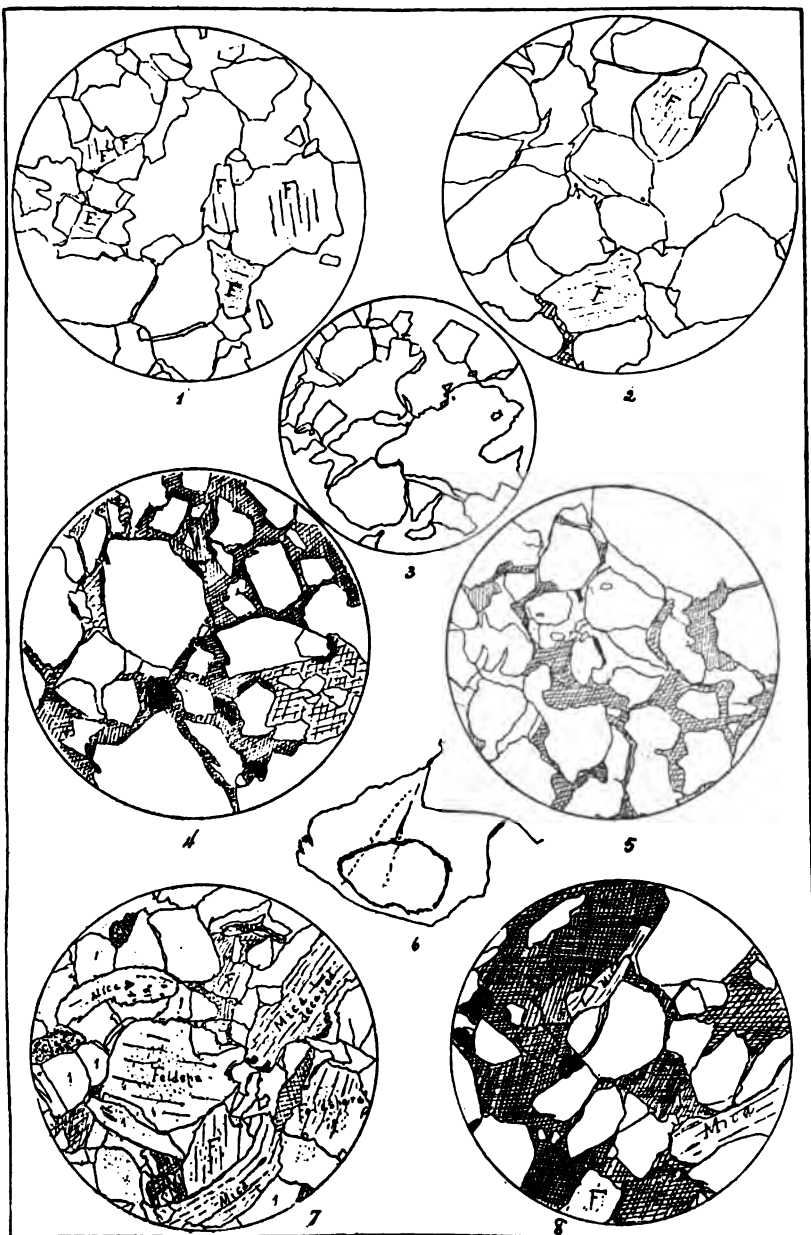


Fig. 2.—Microscopic sections of different brownstones enlarged 44 diameters:

No. 1.—Lumberville feldspathic sandstone—feldspar and quartz and quartz cement.

No. 2.—White Haven red stone, some feldspar, mostly quartz and quartz cement.

No. 3.—An enlarged granule from No. 2 showing its quartzitic character in spots.

Nos. 4 and 5.—Typical sections of the Hummelstown brownstone.

No. 6.—Enlarged view of single grain of the Hummelstown stone showing secondary quartzose character.

Nos. 7 and 8.—Sections of a well known New England sandstone showing its micaceous character.

F signifies feldspar; cross-lined areas aggregates of clay, fine quartz, and iron oxide; very dark shading iron oxide; colorless areas quartz.

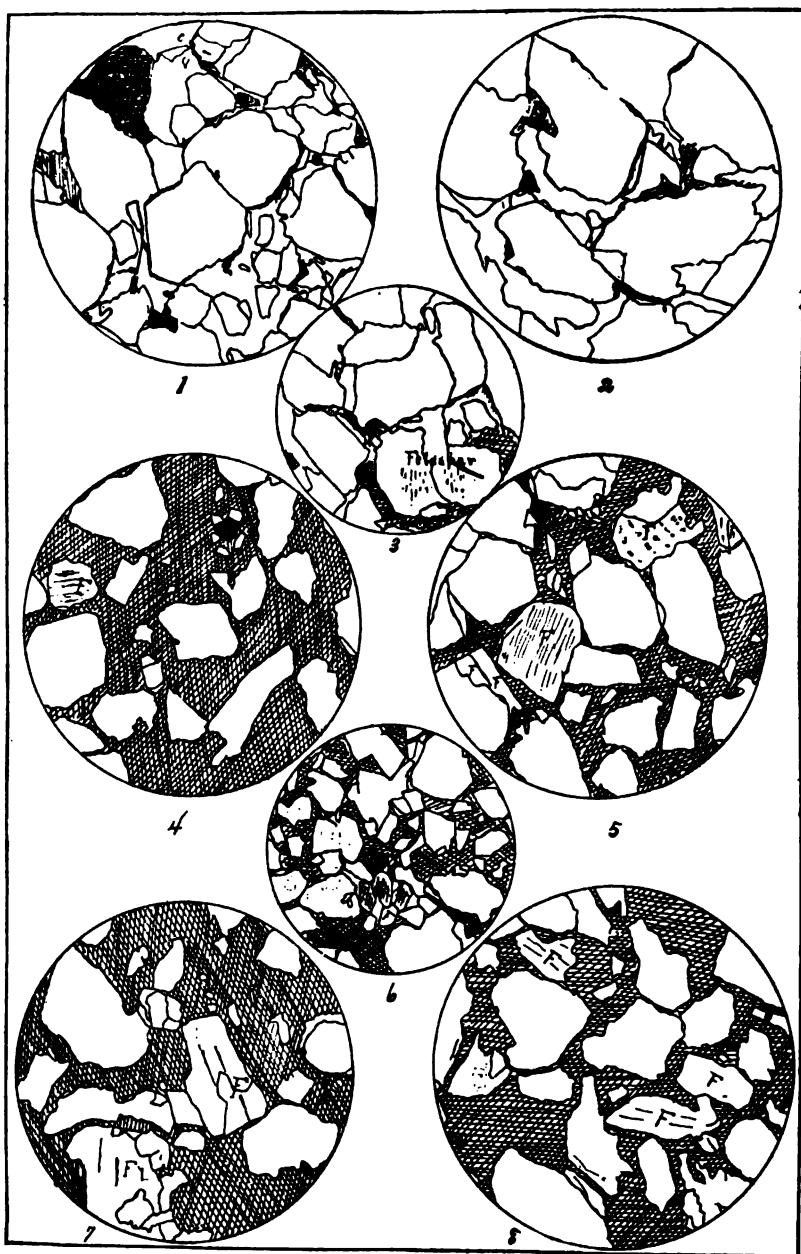


Fig. 5.—Microscopic sections of Hummelstown brownstone, magnified 44 diameters.
 F signifies feldspar; cross-lined areas aggregates of clay, fine quartz and iron oxide; mostly
 clay; very dark shading iron oxide; colorless areas quartz.
 No. 1—Pennsylvania Brownstone Co.'s quarry.
 No. 2—Swatara quarry hard quartzose sandstone.
 Nos. 4, 5, 7 and 8—Hummelstown Brownstone Co.'s quarry.
 No. 3—An enlarged portion of a quartzose area from another part of No. 5.
 No. 6—A less magnified portion, showing a larger area of No. 5.

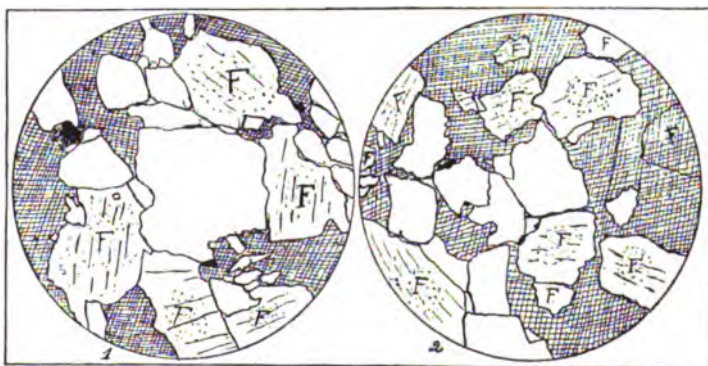


FIG. 6.—Microscopic sections of brownstone from Mitchell's quarry (1) and the Yardley quarry (2). F, is feldspar; the cross-line areas, aggregates of clay and finely granular quartz; the colorless areas quartz grains. Enlarged 44 diameters.

The illustrations, Figs. 2 to 14, indicate what may be seen through the microscope by the examination of thin slices of certain rock. The separate minerals and crystals are indicated by letter or by shading. In Fig. 3, for example, the quartz grains are interlocked and the cement is revealed as calcite in the left hand section, and feldspar in the right hand section. No. 1, in Fig. 2, also shows a section of the same rock. Some views of

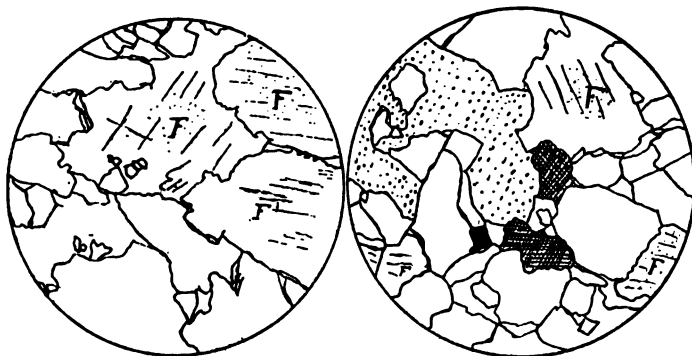


Fig. 3.—Micro-drawings of the Lumberville stone. F is feldspar.

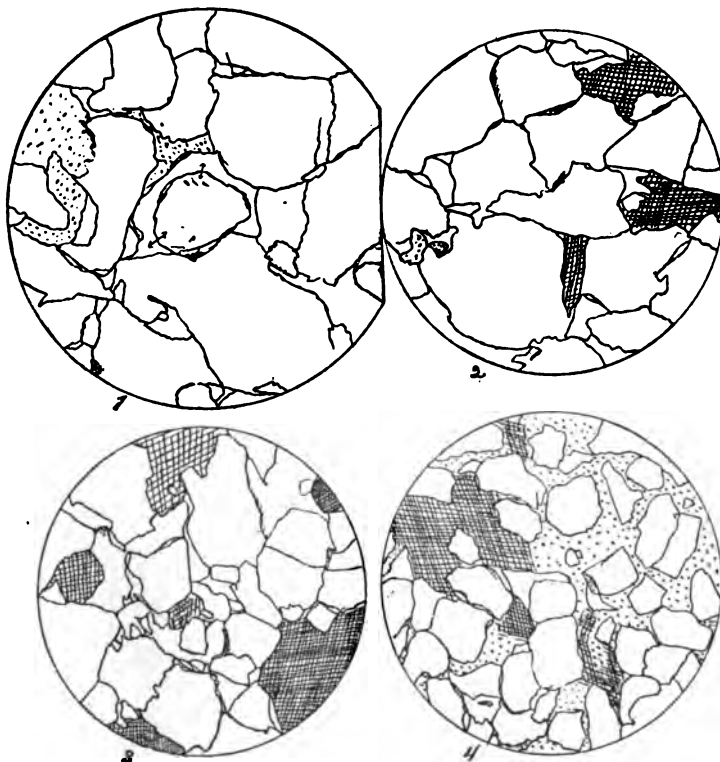


Fig. 4.—Micro-drawings, enlarged 44 diameters, of the Mauch Chunk red stone. Cross-lined areas clay with finely granular quartz, dotted areas calcite, clear areas quartz. Typical quartzite grain in middle No. 1. No. 4, an exceptional calcareous area. All show the interlocking of the quartz grains.

the Mauch Chunk red stone are shown in Fig. 4, where increasing proportions of calcite cement are indicated in the samples progressively from No. 1 to No. 4. The interlocking of the grains is also well revealed. In Fig. 5, the well known Hummelstown stone is exhibited, as also in Nos. 4, 5, and 6 of Fig. 2. The uniform diffusion of the feldspar grains is apparent. The clay and iron oxide cement of the angular grains shows no lamination. The brownstone in Fig. 6 is softer and less brittle than that of No. 1, Fig. 2. Amicaceous sandstone is exhibited in Nos. 7 and 8, Fig. 2.

In all of these drawings the letter F signifies feldspar over its dotted area. Aggregates of grey fine quartz or iron oxide are indicated by crossing hatching over the areas occupied by them. Dotted areas not otherwise marked are calcite. Very dark shading indicates iron oxide, and the colorless areas are quartz. The illustrations in Figs. 2 to 6 inclusive are copied by permission of the Pennsylvania State College from its publications on the Brownstones of Pennsylvania.

Figs. 7, 8 and 9 are reproduced by permission from the Bulletin No. 29, of the Office of Road Inquiry, U. S. Department, at Washington.



Plate II, Fig. 7.

DIABASE, SHOWING INTERLOCKED STRUCTURE.

By permission, from U. S. Department of Agriculture, Office of Road Inquiry, Circular No. 29.

It is the *weathering qualities* of the stone and the reliability of its constituents more than its ultimate strength which concerns us. Both of these properties depend upon the manner in which the minerals are interknit and the strength of the union. The weathering quality depends also upon the chemical composition of the minerals more than it does upon the hardness or the toughness of union which determine its crushing strength. Stones composed of grains loosely held together are weak and their open pore space is great. They lack the coherence necessary to resist abrasion. If they are not held by a cementing mineral they cannot furnish an impervious road ballast, are easily crushed and also rapidly disrupted by the infiltration and freezing of water. When the particles composing the rock are interknit, the stone will be more durable than will one of granular structure. It offers little opportunity for the entrance of water and the minerals are not so rapidly dislodged. Even if the cementing material be weak, the latter stones furnish a better road material than would the first-mentioned incoherent rock. The re-cementation of the rock is more certain when the capillarity and the interlocking arrangements of the grains are high. Stones which are soluble, or possessing soluble constituents would be too readily destroyed by the rains, unless such dissolved materials are retained within the roadbed to furnish a bond for the rock. Stones which have minerals of different degrees of disintegration are so variously affected as to crumble under the action of the elements. For this reason an inspection by the aid of a hand glass or a compound microscope is likely to furnish more serviceable information than would a mere test for the strength of union of the grains. The road surface must be firm and waterproof. It must be made so only by the use of a coherent aggregation having a strong cement. To determine the suitability of any rock for the purpose under consideration, the nature and behavior of its constituent minerals must be known.

The *porosity* of a rock is an important factor, influencing the result of alternate freezing and thawing all its included water. All rocks are porous, but the pores are never of the same size, though they may have a general correspondence in size. By the capillarity of its pores, stones absorb water, and as this is objectionable it may be stated that, other things being equal, a stone of light porosity should possess a low absorptive power and would, therefore, be more durable to moist temperature and frigid climates than when it would absorb a large amount. The absorptiveness of a rock is ascertained by soaking a dried sample in water for ninety-six hours. The increase in weight after saturation is ascertained and reduced to the standard ratio of absorption, which is the number of pounds of water which one cubic foot of rock will take up in that time. This rate is also

expressed in percentage, determined by dividing the weight of the absorbed water by the weight of the dry sample. It may be well to state here that this ratio is not equal to the volume relation which the term porosity expresses.

Hardness of the minerals is requisite in order to resist the crushing action of the wheels. This property is a variation wider than cementation. It involves the toughness of the elements as well as the toughness of the composition. A stone which has both properties is suitable for road surfaces for the conditions which affect endurance of each bit of macadam are similar to those effecting the entire covering. A mineral which is hard enough to resist the attrition of horses' hoofs and also will resist disruption will have the requisite strength for supporting the load. Hardness alone is not the only factor, for the mineral may be hard and yet brittle enough to be easily broken by a slight blow. This brittleness promotes crumbling under the impact of wheels. A quartz crystal is very hard; it is also very brittle. Sandstone, of which it is the main constituent, would, therefore, be totally unfit for road making, however desirable it might be for buildings where it would be subjected to a steady pressure. A rock composed of the hardest minerals or even the strongest minerals might be one of the weakest. It depends upon the size, manner of contact and arrangement. The diabases and diorites have a close interlocking of their minerals and, therefore, afford good service. The granites and syenites do not possess this arrangement or a cementing value as high as the traps. The climatic conditions must be considered in the selection of the stone, for one which would subserve the needs of a southern community would have no service in the northern States, where frost prevails. Nor need the porosity of the rock be considered if it is to be employed upon the arid plains of the west.

The texture of the rock is, of course, important, for the grains may be loosely aggregated or they may be interknit in crystalline form. The latter arrangement must contribute to an increased strength of stone. This relation is revealed by the table on following page.



Plate IV, Fig. 8.

GRANITE, SHOWING GRANULAR STRUCTURE.

By permission, from Circular 29, Office of Road Inquiry, U. S. Department of Agriculture.



Plate III, Fig. 9.

MARBLE, SHOWING GRANULAR STRUCTURE.

By permission, from U. S. Department of Agriculture, Office of Road Inquiry, Circular No. 29.

Taking as a standard 1 cubic meter=1.3 cubic yards of basalt with a crushing strength of 1,500 kilograms per square centimeter (21,335 pounds per square inch), the equivalent necessary quantities of other stones are as follows:

Crushing strength. Lbs. per square inch.	Material.	Cubic yards, cubic metres, or quantity required, proportionate.
21,335	Basalt,	1.00
19,312	Basalt,	1.08
18,490	Diorite; aphanitic greenstone, melaphyr or angite porphyry, gabbro,	1.50
17,068	Granite, syenite, compact quartz porphyry,	1.83
15,645	Porphyry of the granite group, .....1	1.69
14,223	Quartzite graywack millstone grit,	1.64
12,801	Graywack,	2.15
11,378	Quartzite limestone, compact new red sandstone,	2.67
8,534	Jura limestone,	4.00
7,112	Jura sandstone,	7.00
5,689	Chalky limestone,	12.00

The extraordinary decrease in durability compared with crushing strength shows the necessity of great care in testing and choosing stone for road-metaling purposes.

In the following table, average values are given, and the conditions of climate, traffic, etc., are the same in all cases. Under different other conditions it may be said that the differences in durability are less, the less the traffic and the more favorable the weather and the position of the road.*

*Stone, Vol. 14, page 280, 1896.

Description.	Strength of specimen. lbs. per square inch.	Strength per square inch, in pounds.	Weight of one cubic foot stone, pounds.	Ratio of absorption, per cent.
Granites.				
Biotite, glossy feldspar, grey,	56,568	14,127	164.74	0.51
Grey, feldspar in excess, mica, coarser,	47,752	11,938	167.86	0.56
Limestones.				
Dolomite, banded, blue streaks on white; very com- pact; fine grain,	62,832	15,708	179.09	0.07
Marble, color white, slightly seamed,	54,035	13,715	177.84	0.09
Joliet limestone, Ills., color dull grey; fine grain,	63,683	15,771	165.36	1.36
Sandstones.				
Hummelstown,	98,200	14,597	166.10	.....
Rockville, Mo., grey,	23,876	6,000	137.28	5.77
Light red,	29,656	6,849	139.77	4.44
Yellow, fine grained,	11,068	3,900	119.81	9.69
Pure light grey, fine grain,	39,710	10,327	181.01	3.12
Brown, fine grain,	17,593	4,333	126.06	8.99
Light pink, firm, very compact in structure,	66,601	16,818	151.01	1.13
Fine grain, porous,	30,763	7,179	134.16	6.00
Red, coarse granules of quartz enclosed,	40,212	9,385	180.37	0.85
Mottled grey, streaks of blackish clay,	37,693	9,616	142.31	2.42
Pinkish tinge, fine grain,	60,821	14,762	150.33	1.99
Mottled with spots of a yellow and a dark mineral, ..	52,779	13,064	150.38	1.53
Red, Laurel Run,	29,611	17,605	120.23	0.81
Red, conglomerate Trias,	15,582	3,895	148.03	4.43
Volcanic.				
Ash, grey lava,	29,656	7,414	141.65	3.18
Pink,	32,416	8,104	109.20	9.76
Gabbro,	46,244	11,800	.....	.....
Rhyolite,	88,000	27,122	165.10	3.266

Owing to the shortness of the time since the work was organized for this investigation, it has not been possible to prepare a list of tests upon the types of Pennsylvania road stone. The results quoted above, however, will serve as guide to the road master. Moreover, in the detailed account of the distribution of stones in the counties will be found references to places where the best of the material is to be had, as judged from chemical test and microscopic examination. More than one hundred samples of typical rocks from over the State have been carefully examined by the microscope, but without any attempt to describe their appearances, the conclusions were alone given.

THE MINERALS COMPOSING ROCKS.

The minerals entering most commonly into the composition of stones are quartz, feldspar, mica, calcite, kaolin, pyroxene and amphibole. These are aggregated in various proportions and in various ways to form rocks of different textures, composition, hardness and

strength. Others there are of importance and influence but not so freely distributed among the rocks as to seriously enhance or impair their durability.

Quartz, also called silica, is undoubtedly the commonest of these minerals; it is white and hard, but probably neither the strongest nor the most elastic. It may be recognized by its transparency and its slender pointed crystalline form. It is not affected by any acid and cannot be scratched by a knife, though it will scratch window glass. It is the essential element of sandstone or quartzite and should be easily identified by its behavior as noted. The sand of the seashore is quartz.

Calcite is the next most common mineral in rocks. It is either the result of deposition in the sea-forming limestone or dolomite, or it is derived from alteration of the feldspar in igneous and volcanic rocks. Its hardness, strength and elasticity are less than in quartz. The mineral is white, is soft enough to be scratched by a knife and will effervesce when touched by a drop of muriatic acid, or even vinegar, and is quite soluble in any carbonated waters, like rain. The limestone, dolomite or marble, of which it is the essential mineral, will also respond readily to the tests mentioned, though dolomite is the least soluble. The solubility of this mineral detracts from the permanency of the rock containing it when exposed to weather. When the dissolved mineral is removed by the flood, the rock decrepitates. If this constituent is not immediately washed away but remains instead on the road surface and percolates below, the subsequent evaporation of the water will result in its deposition in the interstices of the mass. It will then cement the individual stones and its presence becomes advantageous.

Kaolin is an important constituent of slate and shale, which rocks are of secondary origin. It is one of the softer minerals, light in color, and readily disintegrates under the action of the elements and is a product of the decomposition of feldspar, which, as we shall see, is a very common constituent of the igneous rocks. Indeed, the only exception of the most important rocks not containing feldspar are the quartzites and marbles, with a few limestones.

Feldspar, which is a very common mineral in the massive rocks, is softer than quartz, probably stronger and more elastic, and is little acted on by the common acids under ordinary conditions. It occurs in rhombohedral crystals, usually white in color. In the quarry, its decomposition takes place slowly, but owing to the fact that it is the usual constituent of the older rocks, it exists frequently in an advanced state of alteration. Weathering converts it into kaolin or clay, which rains and wind easily wash away. The slate, shale and clay roads are, therefore, easily effected by winds and rain and their surface are rapidly destroyed.

Mica is also a very common mineral, occurring most abundantly in metamorphic rock. It occurs in thin plates, readily cleaved, providing easy passage for percolating waters by which the clusters are broken. The mineral itself is durable. It may be of any color, the dark ones being more durable than those of lighter tints. When it occurs in small isolated flakes—as it does in sandstone—the mineral is scarcely less resistant than quartz. But rocks containing large clustered mica are to be looked upon with suspicion for road purposes because of the ready separation and easy removal of the clustered mineral. The residual minerals are loosened and the rock will crumble. If the individual particles are large, the rock will very quickly be destroyed.

Some of the heavy, dusty roads in Lancaster county and near Philadelphia are covered with mica spangles.

Pyroxene and amphibole are two dark varieties of minerals resembling one another in appearance to the inexperienced, and have about equal strength and capacity to withstand abrasion and chemical influences. They are always distinctly crystalline, are composed of silica, iron, magnesia and alkalies, are easily seen in the rock, and, with or without mica, are the constituents in varying proportions, of the granites, gneisses and volcanic rocks. They are hard, without being brittle, like quartz, and are usually desirable elements of a rock for road-making purposes. There are several species of minerals under these group names, differing in chemical analysis.

Pyrite and marcasite are two iron minerals easily oxidized and decomposed, staining the rock brown or reddish. Their presence is, therefore, undesirable for building materials, but for road surface coverings, is not serious, unless the amount be very large compared with the bulk of the stone in which it occurs. The iron rust deposit, resulting from its decomposition, acts in a measure as a cement to bind the adjacent minerals of a rock or the broken particles of a macadamized road covering.

THE CONSTITUTION OF ROCKS AND ROAD STONES.

It is evident that the rocks will partake, in their properties, of the nature of the constituent minerals. They will be soft or hard, as the minerals of which they are composed are easily crushed or not. Their brittleness will be dependent upon that of the minerals or upon the state of aggregation of the individual components. Thus, the sandstone, which is composed of quartz, will be hard and brittle because of its chief constituent; limestone will be soluble, because of its predominant calcite, is easily acted on by acid waters; and syenite will be only so tough as the union of its two minerals can make it.

The color, also, of the rocks will be the result of the blending of the distinct colors of the mineral particles composing them. Pure limestone or sandstone are, therefore, white. The size and the distribution of the constituents determine the predominant tint of a massive rock. Fine-grained rocks will have a composite tint, though, on closer inspection with a hand glass, the separate minerals can be recognized by their different colors or shapes. Figs. 7 and 8.

The igneous and volcanic rocks are composed of masses of crystals of quartz, feldspar, mica and hornblende in different degrees, and the distinction between them is based upon the arrangement and relative quantity of the separate minerals. The road master may distinguish between them by the aid of the hand lense. He will find that the granites and igneous rocks show the minerals to be mashed together in the crystalline body like lump sugar, so that the separate minerals can hardly be distinguished, as in the enlarged figure, 8. The volcanic rocks have a distinctly spotted appearance like plums in a pudding, each crystal being individualized. The difference between the rocks is largely due to the rapidity with which they were cooled during solidification. The igneous, which cooled slowly, is completely crystalline, while the volcanic, which cooled rapidly, did not develop a crystalline growth. Fig. 7.

The Volcanic Rocks. First and foremost in importance among the road stones are the volcanic materials, which are uniformly desirable, and nearly all better than the best of other rocks and are therefore to be preferred in places where the cost is not prohibitive. These rocks go under the names of diorite, trap, lava, diabase, gabbro and porphyry. Though of volcanic origin they are not necessarily glassy or shiny. They are all rich in iron, dark in color, hard to break and composed of minerals uniform in strength and in resistance to the action of the elements. They are found in dykes across the country, extruding through the triassic sandstones of the eastern topographic district, or occurring in bosses and in palisades, with loose boulders lying on the surface commonly known as "nigger head." Most of the varieties are useless for building purposes, though they may do good service in foundations. They are close grained and the gabbro is particularly crystalline without interstitial amorphous matter. The grains are interlocked in such a perfect manner as to produce a rock difficult to disrupt, and when we recall the uniform hardness of the constituent minerals, it must be conceded that, as a rule, their resistance to abrasion should be uniform, with an equal wear and durability to all parts of the stone. The decomposition of these rocks yields substances having high binding power because of the presence of the iron and calcite which are released. They will then aid in consolidating the broken bits of stone on the road surface into an impervious, durable crust. Usually the

dike stones are better than the superficial volcanic rock in ratio of about 100 : 80.

As a class they will bear transportation for a considerable distance in competition with many local stones when a permanent road surface is desired. Road expert, James Owen* maintains that it is more economical to haul certain varieties of the volcanic rocks three hundred miles than to employ the local limestone.

Gabbro, which occurs in isolated localities in the eastern topographic division, undoubtedly furnishes the best of the road metal to be had in this State. It is richer in iron, more compact and contains less of the foreign substances than do the other volcanic rocks. Under the compound microscope the green augite minerals are revealed, as also is shown the perfect knitting of its component crystals. It is also better than the diorite, which is often mistaken for granite, though its quartz is hardly visible. It is often called greenstone. No substance in the State is better adapted for roads.

The granites are a crystalline, acid, granular, metamorphic series of rock, composed of feldspar, quartz and mica in considerable varieties of mineral constituency, generally in the above mentioned order of quantitative importance. Sometimes the mica is totally absent. The feldspar may be red, white or gray, and the quartz is usually a fine grained, colorless or white crystal. Locally, the granites may be of value, but they cannot bear the cost of transportation, for very little of the granite can be found whose feldspar is free from secondary alteration, and, if used at all, should not be taken from an old exposure to be used on the superstructure of a road. The quartz is brittle, the feldspar liable to decomposition and the mica is scaly and easily removed from place. The comparative absence of iron bearing substances, and the variation in the strength and character of the several minerals would operate to decrease the strength of the stone while the relatively less amounts of brittle minerals would diminish the power of cementation of its dust. Often dark horn-blende replaces the mica, then the granite is of better grade, but when the mica predominates, as it does in the gneisses, the rock is of inferior quality. The heterogeneous character of the granites gives them a wide range of suitability. Fig. 8.

Gneiss is one of the granitic rocks and contains a large predominant amount of mica, rendering it inferior for road purposes or for building. It is recognized by the laminated appearance. The several minerals are aggregated in separate layers. The term gneiss signifies foliated granite, from which it differs only structurally.

*Transactions Am. Soc. Civil Engineers, Vol. XXVII, p. 609,



Fig. 10.—Gneiss. Photo Micrograph of Rock Section.
Printed by courtesy of Maryland Geological Survey.

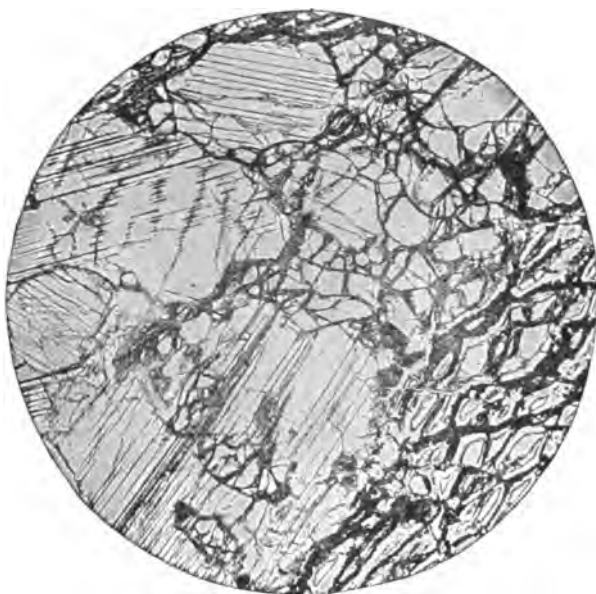


Fig. 11.—Photo Micrograph of Rock Section—Trap Rock, Serpentine.
Printed by courtesy of Maryland Geological Survey.

The gneiss roads just south of Pennsylvania line are not uniform in their durability.

Syenite, another of the varieties of granite, having no quartz but a large percentage of feldspar, is utterly unserviceable because of the high percentage of the two decomposable materials. It makes a good paving block and an excellent building stone where the qualities required are different from those demanded by a superior road metal, where the small broken rock has a large surface exposed to the intimate action of standing water.

As a whole, the granite materials are of second grade for road making purposes, and it is questionable if they are even as good as limestones. They have been subjected to heat and metamorphism, but the presence of the decomposable feldspar and the unequal resistance of their constituents places it out of the class of high grade road metal. They have, however, the advantage of being little affected by freezing and solution because they are compact and therefore absorb little water.

The sedimentary rocks are sandstone, limestone and shale. All when pure are white.

Sandstones are essentially composed of quartz cemented by a little calcite, iron, silica or clay and are of a variety in color and structure, according to that of its main constituent. The presence of iron gives it a pink tint or a brown, while the existence of organic matter is evident by the gray color. The grains of sand may be loosely or compactly cemented by the minerals named above, but as a rule, they are easily separated by a slight blow. This fact may be noted in illustrations, Fig. 2 to 6 and 12. It is rare that the cementing matter binds the grains so firmly that the mass does not easily break down under continued abrasion into incoherent sand. This is particularly true of the light colored sandstones which have essentially no good binding material. Sandstones having a large percentage of calcareous material are even less enduring than those having a clayey cement. Those possessing a ferruginous cement are generally of a strong resistant nature. Hence, the presence or absence of a sufficient amount of good binding material in a given sandstone should be determined before using it upon the roads. There are sandstones which will make fairly good traveling ways and those may be found in the regions covered by a geological formation known as the Catskill (Hugh Miller's Old Red Sandstone). The rocks of the Triassic formation, consisting chiefly of red and brown sandstones, whose individual elements are united by an iron cement, are very serviceable for road building. The ferruginous sandstones of the coal measures are very soft, loosely coherent and porous.

Owing to the very angular form which the quartz assumes when crushed, it mats well together, but the bits are not really cemented

into a mass so are easily dislodged by the blows of horses' feet and the pressure of wheels. The addition of some foreign substance will remedy the difficulty. Clay or iron added in a small proportion to the sand may furnish the desired bond. It is unfortunate that this State is so extensively covered with sandstones which are so totally unfit for the bearing surface of roads, and the only specific directions which can be suggested for the northern and western districts, where these prevail, is to avoid light colored varieties as having no binding materials unless used with an admixture of limestone, iron and clay. As a rule, sandstones are porous and freely admit water to their interior, hence are easily disrupted by frost. In the dry season sandy roads are the worst, in the wet season they are bad enough and it is rare that there is just the proper amount of moisture to render the road surface firm. The weak spots along the Norristown and other turnpikes on the Triassic sandstone attest to this. Some clay puddled into the surface would strengthen the roadbed.

There are four sandstones within the State which are of sufficient quantity and distribution to furnish some road metal, though of very poor quality. These are, 1, the new red or Triassic sandstones, occurring in a broad belt in the eastern topographic district; 2, Mauch Chunk red sandstone, which is very hard and occurs along Lehigh Valley; 3, the Catskill formation, which is interbedded with the shales below and the white sandstone above, extending over the belt indicated by the shaded portion of the topographic map; 4, the Medina sandstone, occurring midway between the two prominent limestones of the State, is a thick pronounced formation comprising the ridges of the middle topographic district.

The Triassic sandstone is fine grained, uniform and not too soft. It shows no disposition to shale when exposed to the weather; on close inspection is found to be fine grained with minute flakes of light colored mica and siliceous cement. This is undoubtedly the best variety of sandstones in the State for road purposes; the others mentioned being of varied texture and cementing material. All of the sandstones have practically no value for highway construction, lacking always some element requisite for a perfectly hard cementing rock. The conglomerate which marks the horizon immediately below all the coals has a siliceous cement, the indurated varieties being of only moderate wearing qualities.

Conglomerates, sometimes called "pudding stone," which consist of pebbles of sand, cemented by the same materials as those which bind the grains of the sandstone, have essentially the same properties and qualities as their allied formation. When the particles are angular instead of rounded, the likelihood of furnishing a good road surface is increased. The conglomerates of the eastern district of the State, having been subjected to greater metamorphic



Fig. 12.—Photo Micrograph of Rock Section of Sandstone.
By courtesy of Maryland Geological Survey.

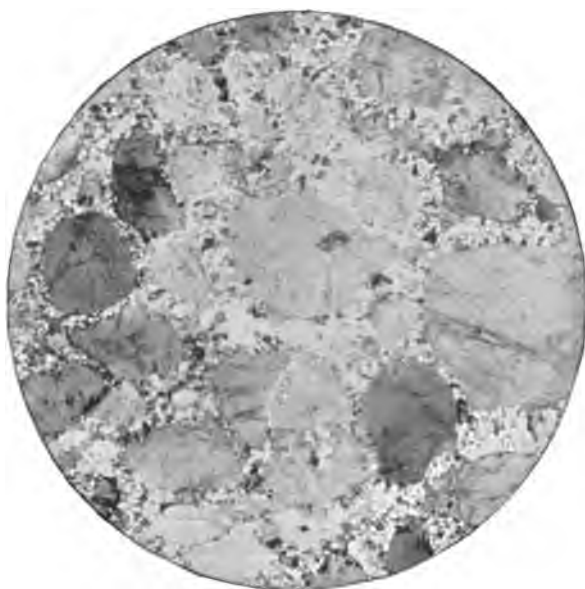


Fig. 13.—Photo Micrograph of Rock Section—Quartzite.
By courtesy of Maryland Geological Survey.

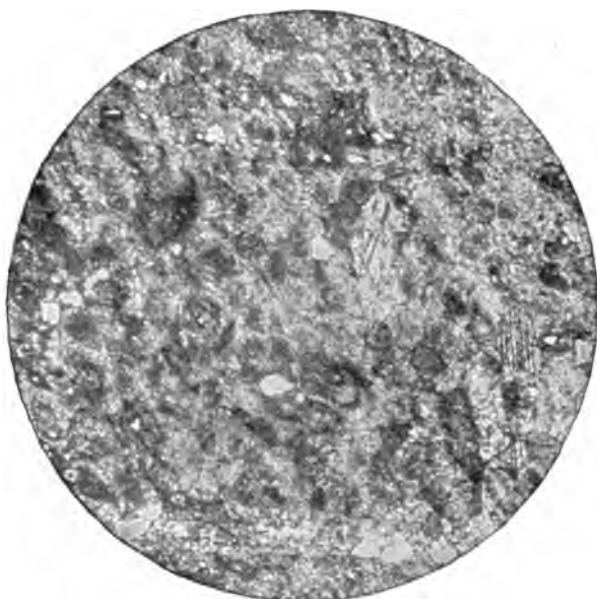


Fig. 14.—Photo Micrograph of Rock Section—Limestone.
By courtesy of Maryland Geological Survey.

agencies than those in the central portion, are of a little higher grade. They may be used a little more freely for road surface if employed in conjunction with some of the waste from the iron mines of their vicinity. Indeed, the abundant deposit of iron ore which occurs in the eastern and middle districts, too lean for furnace use, could be employed to great advantage as an artificial cement by being spread over the surface of the roads simultaneous with the conglomerate or sandstone. Still, they have only temporary coherence and have defied the best efforts at construction.

Quartzite, occurring in isolated areas of the eastern district, has been used locally with success as a road metal. It is essentially a sandstone, which had been subjected to a high heat, and is consequently extremely hard, tough, fine grained and homogenous. Some quartzites are too fissile for turnpikes. Fig 13.

Flint or chert, which is still harder than the preceding varieties of sandstone, is of local occurrence and used for road covering. In France, on account of its great abundance, is a very common surface material. This substance, however, does not occur in considerable quantities in original beds, but is largely mixed with lime—in fact it is a siliceous concretion of limestone. When exposed to the weather, chert decomposes slightly, a little being dissolved, leaving a spongy mass. This material furnishes a good road surface, hard, compact and almost free from dust. The best instance of this nature of roads may be cited from the mining regions of southwest Missouri, where the chert waste is utilized to make excellent road coverings. As the fragments of broken chert are angular, they are easily rolled into place, while the limy constituent serves to bind them.

Gravel is a siliceous material very largely used for road coverings, though it is not wholly recommended by the road authorities of either Massachusetts or New Jersey, where the unmixed gravel has been employed at the request of the local authorities to save expense. It shows marked effects of travel and “as the saving in expense of this construction over the cost of a macadam road will not equal to the cost of maintenance compared with the maintenance of a macadam road, screened gravel roads do not seem to be economical.”* To be serviceable for road coverings, gravel must have the proper degree of coarseness, must have a matrix which will cause it to bind in the roadbed, and also must contain some soft mineral. As gravel is usually the detritus of some conglomerate of their formation and is not indigeous to the place where it is found, it is usually a washed product, free of any soft elements or those which might furnish a desirable matrix. Hence, such gravel as is found in the bed of a stream has no value for road purposes. Water worn gravel will not

*Massachusetts Highway Commission Report 1900, page 32.

key well. The loose, smooth pebbles would slip upon each other and allow wheels to sink in the roadway, and no amount of rolling would bind them to a union. If, however, some binding materials be mixed with it, or it be rolled with clay, a hard, firm packing may be obtained, but even it will require watchfulness to preserve the surface.

Gravels, however, obtained from the table lands, associated with other softer fragments which have been displaced from their habitat, are capable of being packed promptly and firmly and with rolling may supply the quantity of powdered rock which is necessary to knit the fragments together. This is true of the broad mantle of glacial waste which is so largely relied upon by the road makers of the northwestern district of the State. This foreign material contains iron bearing substances and detritus from the granites of Canada, which were borne down on to the soft rocks of the States south of the great lakes during the prehistoric times, on the flanks of the glaciers. In the eastern part of the State the gravels also have a wide distribution, and for practical purposes may be called a local deposit. They are loamy or arkose. Some of these gravels are better than crushed rock; in other cases, experience has shown the reverse to be true. They have considerable advantage over prepared macadam in that they require no crushing, though on the other hand they had been partially leached by water. The glacial transported material, even in its poorest form, is often usually better than what can be had from the underlying rocks. If care be taken in the selection of the gravel, that it is not too clean and free from iron and clay, a possibly durable surface is obtained after careful rolling. But as has been stated above in speaking of sandstone roads, the replenishment must be perpetual.

In the sections of the State where the gravel road must be constructed, it is highly essential that this form of improvement should receive great care in the selection of material. Assuming local stone in both cases, it can be built for less money than would build a macadam road, but its durability is not so high. It has given excellent service for the travel of moderately heavy wagons, but it would be useless for heavy traffic. The glacial gravel roads of Warren county have given good service, but now after five years will require entire reconstruction.

Care must be exercised in watching the loaders of the wagons that they do not throw more of the sand or clay, with which the gravel is buried in the pits, than has been determined upon for binding purposes. The amount of clay which should be mixed with the gravel on a sand surface, or the amount of sand which would furnish sufficient binder on a clay foundation must be determined locally. The great difficulty in reaching a decision lies in balancing

the elements. Whatever may be the mixture, it is one which would make a perfect road only in a given season. Roads of this kind, which are excellent in summer, might frequently be impassable in winter. Therefore no graveled roads should be laid unless the extremest of care is given them in the selection of material, the mixture and the construction. With the aid of a high degree of skill, New Jersey has succeeded in making excellent gravel surfaces through the pine districts. These should be the pattern for our road men of the northwest.

Limestone, which was formerly regarded as one of the best rocks for road surface, has finally proved to be unsatisfactory as a good, natural material. There are many grades of limestone of varied composition, and more abundant than any other stone in Pennsylvania except sandstone. Its distribution is wide, though the several varieties of limestone have different degrees of durability. It is easily crushed, is a cheap macadamizer, and binds well. Composed of calcite, with a cement of silica or clay, it is easily acted on by water, quite soft, and though the compact is easily disintegrated by the natural and dynamic forces to which it would be subject when used on a road surface. Its resistance to wear is low, but its cementing qualities are high. Its softness under the action of wheels results in the formation of a large amount of dust which makes the much traveled roads undesirable during dry and windy periods. For city use it is decidedly objectionable. The mud which it forms in the wet season is ruinous to carpets. Marble is the lowest grade of limestone for this purpose, being too closely crystalline. The fine grained varieties are preferable. Dolomite, which contains considerable magnesia, is softer than pure limestone. It cements well but is not so durable. When clay is present in any of the varieties, its effect generally is to improve its value as a road material, but no limestone is to be very much recommended where heavy traffic is present. It is always better than the aboriginal mud. Fig. 14.

Of the varieties of limestone, that which is geologically known as the Helderberg, is universally the strongest, having the highest resistance to wear, producing the least dust and possessing a superior cementing power. It is reported at several points in the anticlinal folds of the middle district. All points considered, it is more economical there than trap would be. That which is known as the Ligonier is next in grade and quality. Ranking well with it is the dark ferriferous limestone, occurring in the western counties of the State. The lowest grade of limestone is the Trenton, which is found in the valleys of the middle district. The dark colored limestones furnish a more agreeable surface for the traveler than do those of light, color which are so highly reflective in the summer light. If pinkish in tint they are still more desirable.

Marble is the lowest grade of limestone for this purpose. Being crystalline, they are very brittle, quickly turn to dust and are not acceptable for any road surface. Their structure is granular. Fig. 9 reveals the pronounced tendency to form rhombic grains and emphasizes the weakness of the stone. Marble quickly passes into dust. Its appearance reveals this deficiency.

Shales or slates are found as independent strata among the other sedimentary limestones and sandstones. The term shale is, unfortunately, not in as common use as is the indiscriminate slate or soapstone. The true shale is made of clay, hardened, and when pure is known as argillaceous shale. Its color may be from that of pure kaolin, which is white, to a dense organic black color with intermediates of pink or red, according to the amount of iron which may be present. The shale may also have an admixture of sand or lime, making it a sandy shale or a calcareous shale. In the eastern district there is in addition a shale which is largely micaceous.

Being composed of a material as soft as clay, the shale is usually crumbled in the process of weathering. It is the soft underlying layer of the hard sandstone ledges of the ravines in the western district. It is also the formation which furnishes the water courses or valleys in the middle district. Its inability to withstand the weather, as revealed by its behavior in nature, furnishes the clue to its suitability for road purposes. Wherever the shale occurs in sufficient body, the valley is characteristically broad, flat and fertile. This occurs along the Delaware, extending in a belt with the mountains across several counties in the eastern district. Of the three varieties of shales, the sandy shale is the most desirable for a top dressing. It may contain a sufficient amount of sand and clay to make a moderately hard surface that will pack well during three-fourths of the year. But it is soft and its absorbent qualities would detract from its service during the spring months. It is easily ground and forms a fine dust when dried, and a sticky, pasty mud when wet.

The calcareous shales often contain a small amount of lime or iron, and either of these acts as a cement, which, with sand or sand clay would make a fair surface. The argillaceous shales are the least adapted for substantial road covering because composed entirely of the one non-cementing material.

The distinction between sandy, argillaceous and calcareous shales is easily made. The first named is gritty, and when cut with the knife grates disagreeably; the second cuts smoothly like a piece of wax. No grit is felt when ground between the teeth. Calcareous shales effervesce with a drop of acid or vinegar.

Shales abound in every district though they are not by any means highly desirable, yet may nevertheless be employed to advantage

better than any other local stone which can be had at moderate expense. As a rule, the clay element in highway construction is undesirable. Yet in regions where the sandy shales predominate they may be acceptable, particularly if well sprinkled during the dry season, and the road scraper be conscientiously kept from it when repairs are made.

In the counties of the western district the sandy shales are found in abundance among the coal measures, and many of them constitute excellent material where the traffic is not heavy. They are usually of a dull color and therefore agreeable to the eye. They are not sufficiently valuable to transport, but are worthy of attention where they occur.

The shales which occur in the eastern district crossing the counties of Berks, Cumberland, Dauphin, Franklin, Lebanon and Lehigh, are capable of furnishing excellent surface when properly cared for. The material does not bind well but is moderately tough; affords comfortable travel and requires little work to keep up the condition of its surface. In the dry seasons of the year there are no pleasanter roads than those of Pike county between Bushkill and Point Jervis. This shale is geologically known as Devonian. It maintains its character throughout the belt across the Maryland line into Washington county, where similar roads are enjoyed.

However well ordinary shale roads may be maintained during the pleasant season of the year, they are not permanent, will require considerable repairs and are almost impassable in wet weather. Even in these regions a stone covering well rolled is requisite.

Slates are of the same composition as shales, but have been subjected to heat in the process of mountain building, and are therefore more compact than they were in their original state. Their behavior, therefore, is not different from that of the shale or its derivative, clay. Being harder, it would serve better but will require the addition of some cementing material to give it endurance.

In the opinion of the writer, clay, shale or slate is fit for road use only after being burned. In its raw state it has not the desirable elements for permanency. When mixed with sand in proper amount and burned in a kiln, the material should be used over the surface in the loose state or after being moulded into brick. Mr. F. Plumb, of the Illinois Clay Workers Association, suggested the construction of a traveling clay kiln for burning local product and spreading it on the spot. He proposed to dig the plastic clay by the roadside, passing it through a pug mill, expel the chemically combined water and render it non-plastic. This vitrified clay would then be used as a veneering on the surface. Six cubic feet would be required for each linear foot of road nine feet wide and eight inches thick.

Field Stones or Erratics. It is common practice to crush the loose boulders plowed up in the field or gathered along the roadway. This is a convenient, cheap and quick method of acquiring material for covering, but the practice is questionable unless the cobble has been selected with some degree of discrimination. The boulders are of the local formation, have been exposed long to the elements and, having lain on the ground or been buried in it for a time, would be more or less completely decayed from contact with the humic acids of the soil. Many are sound, however, because only freshly removed from place or sufficiently durable to withstand the action of the elements. But most of them are so far decayed as to be utterly worthless. They are the more unsuitable in condition according as they have been the longer exposed in the field.

Often their appearance may at once indicate how far advanced the rottenness is. In limestone regions the spongy nature or porous condition is evident. The sandstone cobbles easily fall to pieces when roughly handled. The micaceous rock will have a dusty sparking mass about it. A few blows with a sledge will best prove their unsoundness. Those which crumble readily and powder freely may be rejected safely. If there are many such boulders that fly into fragments, the supply may be passed by as affording material which, compared with the rock in place, is at least unfit. Rocks breaking into small blocks along a pair of parallel cleavage planes may be accepted as, at least, in a sound condition.

Iron Ore. At many points in the limestone regions, as well as near the massive rocks, are found numerous deposits of bog iron ore and other bedded iron ores whose value for road making is not to be ignored. Many of these deposits have ore too lean to be worked in the furnace, and there are in addition waste heaps of the old iron mines which afford abundance of material. These substances are suitable for road covering as cement to the sands or sandy shales which occur in their vicinity and which are likely to be the sole available road coverings. The iron ores are particularly useful for binding the bits of stone together, and as the cost of their extraction is quite low, they are mentioned among the list of road making materials. They cannot be used alone and are serviceable merely in mixtures.

Slag. Blast furnace slag has been employed in its crushed state for road covering. It contains the chemical elements for a good road material, though it is too freely soluble when under the water for a prolonged period. It competes well with the low grade local limestones, but will not admit of hauling a great distance. Its rank in the list of materials is below the best granite and above most of the limestones. In New Jersey several experimental stretches of road were veneered with it and in a few regions it was

used as a foundation material for trap surface. In those instances it had proved of excellent quality. In one locality it costs 44 cents per square yard, laid, while the high grade stone costs 54 cents.

The slag blocks used in Philadelphia, laid on a Telford foundation, are exceedingly durable. They, however, make a very slippery surface, which is decidedly unsafe.

BRICK PAVEMENT.

Brick pavements are quite extensively used in our western cities though they are still in an experimental state. They are laid on a foundation of 4 inches to 6 inches of cinder, sand or concrete, thoroughly rolled, over which has been spread a thin cushion of sand from one to two inches thick. On this the bricks are laid flat with the longer dimension parallel to the street. They are rolled, surfaced and then grouted by working sand, asphalt or cement between the joints to act as a filler. The bricks are of a peculiar kind of hard burned quality different from the common brick. The clay from which they are made is one which is incapable of fusion under a high heat, having little lime, magnesia and the alkalies with less than three per cent. of iron. The clay should not effervesce with acids, should be capable of making, with water, a paste that is plastic, and when dry should make a solid mass, breaking when struck into scales. The clays having a soapy feeling are of better quality than those which are rough to the touch. As a rule, it may be said that the pure fire clays and shales which occur in connection with the coal beds are of the best quality for vitrified brick.

Almost the entire region included in the northwestern topographic district of the State is underlaid by coal measures. These contain desirable clays for brick making.* As this region is a district over which little natural road making materials are to be found, it would seem that the utilization of these shales by the erection of local brick kilns would establish an industry of no small amount and furnish a durable road covering in the region where good surface is utterly impossible without imported rock. According to the data

*The School of Mines of The Pennsylvania State College has issued a free Bulletin describing the clays and clay industry of the western section of the State and has in preparation another which will comprise the north central region of Pennsylvania.

obtained from 26 city engineers throughout the state, the prices paid for the pavement varies from \$1.10 to \$1.60 per square yard, including gutters, curbs, &c. The cost is influenced by a wide varieties of factors, that of transportation being the greatest, but it would seem that municipal enterprise should establish kilns for baking brick out of the underlying shales and thus reduce the cost per thousand below \$10.00, which appears to be the minimum figure. If it is possible, as the author is disposed to recommend, brickways might be laid into county districts; a width of seven feet could be laid on a secure foundation at a cost of not to exceed \$2,500 per mile. The popularity of the brick pavements in the west has led to their rapid extension to the borough lines, and in regions of moderate traffic this price would not be excessive when one recalls that the life of a brick pavement is about twenty years and the annual cost of repairs is less than \$60.00 for the first five years. The loss in broken brick average between 2 and $4\frac{1}{2}$ per cent. for eleven cities, where there has been much handling.

A very good example of a seven feet country brick way is furnished near Franklin, where two miles of such a surface is laid along the river; and now, after three years, is in excellent condition, having had no repairs during that time, notwithstanding the heavy traffic to which it has been subject. It was built by excavating to a depth of 6 inches on one side of the center line of the road and spreading 2 inches of sand for the brick, with a sand filler on top. The soil on which it was located is a gravelly loam to hold the pavement in place it was curved with a strip of white oak projecting two inches above the pavement on both sides.

The ordinary city construction includes a foundation 14 inches deep. Into this is laid 8 inches of broken local stone, 2 inches of sand and 4 inches of brick.

Brick pavements are as strong as granite and are noiseless, fairly clean and more durable than the best limestone macadam. With a minimum traffic of three tons, brick is superior to granite. It requires no high order of skill to lay and repair it. The disadvantage arises from a lack of uniformity in the material and the risk of introducing some brick which are soft and porous. These objections, however, may be obviated by a careful inspection of the material used. Below are given a number of tests made upon brick which were of a size 3—4 by 3—4 by $1\frac{1}{2}$ placed on end between pieces of soft pine, about $\frac{1}{4}$ inch thick and ground to a true size on an emery wheel.*

*Engineering and Mining Journal, William Kent.

	Specific gravity.	Per cent. Absorption.			Crushing strength, lbs. per square inch.
		Three days.	Five days.	Ten days.	
No. 1,	2.185	3.79	3.92	4.06	{ 10,120 minimum.
No. 2,	2.305	3.18	3.19	3.37	{ 12,920 maximum.
No. 3,	2.227	1.87	2.20	2.70	{ 9,893
					{ 9,386
No. 4,	2.347	3.10	3.12	3.32	{ 9,361 minimum.
No. 5,	2.415	7.67	7.96	8.71	{ 10,000 maximum.
No. 6,	2.350	7.11	7.43	8.70	{ 8,173
No. 7,	2.286	3.26	3.38	3.64	{ 8,862

For comparison, the following tests of common building brick are given. Results in pounds per square inch:

GOOD AVERAGE HAVERSTRAW BRICK, TESTED BY MR. ABBOT.

	Maximum.	Minimum.	Mean.
Whole brick on end,	3,060	1,600	2,065
Half brick on flat side,	4,153	2,669	3,371
Half brick on small side,	6,400	2,900	4,612

EXPERIMENTS BY PROF. PIKE, MINNEAPOLIS, MINN.

St. Louis, Mo., brick, flatwise, 6,417 pounds; edgewise, 4,080 pounds.

Hastings red brick, hard, 2,017 pounds; medium, 2,012 pounds; soft, 1,748 pounds.

A series of tests by the National Brick Makers' Association is quoted below from their report of 1897, page 165 *et seq.*

Designation of sample.	Clay Material Used.	Dimensions of Brick.	Per cent. loss in rattler test.	Per cent. gain in absorption test.	Specific gravity.	Modulus of rupture in cross breaking.
1	Shale,	8 x3½x2	13.72	1.53	2.41	26.69
2	Shale,	8 x4 x2½	14.53	1.15	2.34	26.68
3	Shale,	8 x4 x2½	11.46	1.17	2.37	26.19
4	Shale,	8½x4 x2½	12.94	1.83	2.33	24.88
5	Shale,	8½x4 x2½	10.80	1.72	2.35	21.04
6	Mixture,	9 x4 x3	9.88	4.09	2.24	23.42
7	Shale,	8 x3½x2½	12.98	2.05	2.33	24.79
8	Shale,	8 x4 x2½	12.34	0.92	2.41	27.80
9	Shale,	8 x4 x2½	10.12	1.05	2.36	26.12
10	Shale,	8 x4 x2½	12.74	1.85	2.22	29.88
11	Shale,	9 x4 x3	10.28	2.48	2.27	20.56
12	Mixture,	9 x4 x3	11.85	2.98	2.22	24.23
13	Fire clay,	8½x4 x2½	10.87	4.78	2.20	22.21

THE RESULTS OF MICROSCOPIC EXAMINATION OF SPECIMENS FROM 150 LOCALITIES.

Made by Mr. W. L. Affelder, at State College.

The Diorites from Chester, Berks and Adams counties was almost identical in all cases. Dark, mottled and compact, the quartz is a cementing bond and the feldspars are unaltered. The Diabase of Adams county shows cleavage and zonal structure. The microcline reveals the characteristic "window grating" structure and the feldspars are without signs of decomposition. The Diabase from Berks county shows the olivine altering to serpentine though the stone is still in good condition. The serpentine from Thornburg is not quite completely stable, some olivine crystals being still present. All the samples which were examined show the presence of some of the soft talc. Gneiss from St. Peters is composed of interlocked crystals in an excellent state of preservation.

The Montgomery county marbles show a calcite cement in minute crystals. The Coplay limestone is fossiliferous. The Avondale marble contains mica. The marble of Wrightsville is too friable for roads because of existence of grey calcite crystals in advanced state of alteration. The valley limestone of the middle topographic district is highly magnesian, fine texture, with calcite cement and abundant fossils. The Lower Helderberg limestone of the hills of the middle district are typical calcareous deposits, fine grained and strong, with enough iron present to stain the stone on exposure. The limestone of Erie county is of oolitic structure with a siliceous

cement. The fishpot limestone of Greene and Washington counties, so extensively used for roads, is made up of minute crystals of calcite broken by numerous fossil remains and a thread of larger crystals of calcite.

The sandstones of the ridges and hills in the middle district are quartzitic and strongly coherent. Iron and mica occur in them all to slight degree. From Tioga the old red sandstone contains magnetite. Some hornblende is discovered in the Centre county Catskill sand. That from Lanesboro contains some clay as well as magnetite. The Triassic sandstone of Lambertville contains a little calcite and siliceous cement to the partially rounded grains of quartz. Some ferrite occurs in the Hummelstown stone.

Results of Tests.—An examination of the results obtained by prominent engineers and neighboring State's Geological Survey upon the various rocks has revealed great differences in the resistances to the several forces to which they were subject. As may be inferred from what has already been stated in the text above, rocks of the same class would manifest as wide difference of value as those which exist between rocks of different classes. The strength varies in no ratio with the resistance to wear. So, too, rocks may be tough and yet have no re-cementation qualities in their dust, but the inspection of the table below will show that the volcanic rocks in the main have the highest resistance; the limestones come next in rank. It will be remembered that the results of the tests which are high, correspond to material of good quality, and those rocks whose values are above 20 in cementation and 17 in wear are excellent. Those having co-efficients which are below six are poor. With this general statement it will be recognized that the highest grade of limestone shows a value less than the lowest of the trap rocks; with the granite and schist between the two, the gneisses and sandstones at the bottom. While this is a general statement and holds true for these types of rock, individual specimens or isolated deposits of one or the other may have a higher or lower grade. It is safe, where the nature of the travel and the equipment of the road office will admit of it, to employ trap rock in preference to any of the others. There is plenty of it in the State, and if the railroad transportation rates are made reasonably low, it could be laid down with advantage anywhere in the State. When, however, a closer economy must be exercised, at least in first cost, it would be advisable for the road master to make a test of the several available road materials and determine with the local conditions which will prove the most durable. Indeed, it would be safer if all selections of road covering were deferred until tests had been made of the product of the particularly quarry from which it is intended to be removed.

A series of tests by the National Brick Makers' Association is quoted below from their report of 1897, page 165 *et seq.*

Designation of sample.	Clay Material Used.	Dimensions of Brick.	Per cent. loss in rattler test.	Per cent. gain in absorption test.	Specific gravity.	Modulus of rupture in cross breaking.
1	Shale,	8 x 3 1/4 x 13	13.73	1.52	2.41	26.69
2	Shale,	8 x 4 x 13 1/4	14.53	1.15	2.34	26.63
3	Shale,	8 x 4 x 13 1/4	11.45	1.17	2.37	26.15
4	Shale,	5 1/4 x 13 1/4	12.94	1.53	2.33	24.98
5	Shale,	5 1/4 x 13 1/4	10.96	1.72	2.35	21.04
6	Mixture,	8 x 4 x 13	9.96	4.59	2.34	26.43
7	Shale,	8 x 3 1/4 x 13 1/4	13.96	0.92	2.33	24.73
8	Shale,	8 x 4 x 13 1/4	13.34	0.92	2.41	27.99
9	Shale,	8 x 4 x 13 1/4	10.13	1.05	2.36	26.13
10	Shale,	8 x 4 x 13 1/4	12.74	1.35	2.33	29.53
11	Shale,	8 x 4 x 13	10.26	2.43	2.27	26.54
12	Mixture,	8 x 4 x 13	11.95	2.36	2.23	24.33
13	Fire clay,	5 1/4 x 13 1/4	10.37	4.13	2.39	22.21

THE RESULTS OF MICROSCOPIC EXAMINATION OF SPECIMENS FROM 150 LOCALITIES.

Made by Mr. W. L. Aftelder, at State College.

The Diorites from Chester, Berks and Adams counties was almost identical in all cases. Dark, mottled and compact, the quartz is a cementing bond and the feldspars are unaltered. The Diabase of Adams county shows cleavage and zonal structure. The microcline reveals the characteristic "window grating" structure and the feldspars are without signs of decomposition. The Diabase from Berks county shows the olivine altering to serpentine though the stone is still in good condition. The serpentine from Thornburg is not quite completely stable, some olivine crystals being still present. All the samples which were examined show the presence of some of the soft talc. Gneiss from St. Peters is composed of interlocked crystals in an excellent state of preservation.

The Montgomery county marbles show a calcite cement in minute crystals. The Opeley limestone is fossiliferous. The Avondale marble occurs in ca. The marble of Wrightsville is too friable for roads because of existence of gray calcite crystals in advanced state of alteration. The valley limestone of the middle topographic district is highly magnesian, fine texture, with calcite cement and abundant fossils. The lower Helderberg limestone of the hills of the middle district are typical calcareous deposits, fine grained and strong with enough iron present to stain the stone on exposure. The limestone of Erie county is of oolitic structure with a siliceous

cement. The fishpot limestone of Greene and Washington ties, so extensively used for roads, is made up of minute crystals of calcite broken by numerous fossil remains and a thread of crystals of calcite.

The sandstones of the ridges and hills in the middle district are quartzitic and strongly coherent. Iron and mica occur in them to slight degree. From Tioga the old red sandstone contains hornblende is discovered in the Centre county kill sand. That from Lanesboro contains some clay as well as netite. The Triassic sandstone of Lambertville contains a little netite. The partially rounded grains of quartzite and siliceous cement to the Hummelstown stone. Some ferrite occurs in the Hummelstown stone.

Results of Tests.—An examination of the results obtained by prominent engineers and neighboring State's Geological Survey upon various rocks has revealed great differences in the resistances to several forces to which they were subject. As may be inferred from what has already been stated in the text above, rocks of the same class would manifest as wide difference of value as those which exist between rocks of different classes. The strength varies in no ratio with the resistance to wear. So, too, rocks may be tough and have no re-cementation qualities in their dust, but the inspection of the table below will show that the volcanic rocks is the main class the highest resistance; the limestones come next in rank. It will be remembered that the results of the tests which are high, correspond to material of good quality, and those rocks whose values are above 20 in cementation and 17 in wear are excellent. Those having co-efficients which are below six are poor. With this general statement it will be recognized that the highest grade of limestone shows a value less than the lowest of the trap rocks; with the granite and schist between the two, the gneisses and sandstones at the bottom. While this is a general statement and holds true for these rocks, rock, individual specimens or isolated deposits of one of the rocks may have a higher or lower grade. It is safe, where the travel and the equipment of the road office will employ trap rock in preference to any of the others. Then, if of it in the State, and if the railroad transportation is not reasonably low, it could be laid down with advantage in the State. When, however, a closer economy is required, at least in first cost, it would be a desirable for the road office to make a test of the several available road materials and determine the local conditions which will prove the most durable. It will be safer if all selections of road covering were made on the basis had been made of the properties of the particularly quarried stone it is intended to be removed.

Stones.	Coefficient of wear.	Cementation coefficient.
Diabase, trap, Chester county,	23.40	13
Diabase, trap, Massachusetts,	16.02	22
Diabase, trap, Frederick county, Md.,	22.10	16
Diabase, coarse, Massachusetts,	9.28	24
Diabase, fine, Massachusetts,	20.33	62
Diabase, Massachusetts,	16.79	14
Gabbro, Rockhill, Pa.,	17.46	12
Gabbro, Baltimore county, Md.,	19.20	4
Gabbro, Hartford county, Md.,	12.70	6
Diorite, Cecil county, Md.,	12.00	1
Granite, Massachusetts,	9.77	12
Granite, Massachusetts,	12.16	16
Granite, Howard county, Md.,	12.00	3
Limestone,	9.38	15
Limestone, siliceous, New York,	12.01	17
Limestone,	8.26	10
Limestone, Helderberg,	9.00	20
Limestone, Ligonier, Somerset county,	10.00	25
Limestone, Trenton, Franklin county,	6-16	7-18
Schist, Massachusetts,	12.21	11
Schist, New Jersey,	8.04	27
Sandstone, Triassic, Maryland,	7.00	28
Sandstone, Catskill, Maryland,	12.30	18
Sandstone, Medina, Massachusetts,	17.48	6
Sandstone, Oriskany, Maryland,	7.90	1
Conglomerate, New Jersey,	11.57	12
Slate, Massachusetts,	8.48	29
Chert, Missouri,	8.35	7
Slag, Howard county, Maryland,	9.00	2
Field stones, Massachusetts,	8.5-14	7-20
Marble, Massachusetts,	7.20	8

Below will be found a table quoting the results of tests for wear upon various rocks, standardized by the French system. The highest and the lowest figure obtained for each class of rock are given. A table is also appended furnishing the results of tests made upon the several varieties of rock for resistance to crushing, the ratio of absorption and the influence of frost.

Kind of Stone.	Highest Result.		Lowest Result.	
	Coefficient of wear.*	Coefficient of wear.*	Per cent. of wear.	Per cent. of wear.
Diabase, trap,	30.40	1.31	9.28	4.31
Granite,	21.16	1.90	8.41	4.76
Felsite,	19.91	2.01	12.30	5.25
Gneiss,	23.02	1.73	5.01	7.98
Limestone,	17.20	2.38	6.31	6.34
Schist,	12.52	3.19	4.87	8.20
Quartz,	20.24	1.97	9.07	4.41
Field stone, erratics,	19.19	2.06	5.43	7.30

*On the French system.

WHAT IS THE BEST MATERIAL TO EMPLOY?

Selection of Stone.—The road master must select material within his own district which will offer the highest resistance to wear and possess the strongest cementing material. These are the properties demanded. The formation which contain the rocks best capable of supplying this demand will be selected, provided they can be delivered cheap on the ground and rolled into place with the equipment he has at hand. It has been seen that no substance shows an exceptional quality in all the tests. No material stands the superior of all the others in the lines in every road-making essential. Hence, it is not easy to name a rock which will have universal commendation as the best road surfacing. In no instance does a given rock show the same approximate rank in all its properties. A certain stone may be superior in strength, but very weak in the elements that contribute to the re-cementation of its broken particles. Another stone may be so soft as to produce, under travel, more dust than can serve as a cement and yet it joins well. There appears to be

no relation between the findings of the various tests, and no clue has traced between the abrasive strength of the stone and its re-cementing qualities. These are independent factors in the value of the stone. The first depending upon the internal constitution and toughness of the minerals, and the second upon the existence of a soft mineral of iron and lime. The physical inspection with a lens or a microscope affords the best clue to these factors. How they are to be rated in a final determination of the merit of the stone is a matter for each highway builder to fix. He has a considerable body of literature to refer to, and will find therein many statements regarding the utility of road metals which are at variance with one another. This naturally arises from the difference in the value assigned to the influences which the cost of the several available substances may have as compared with their co-efficients of wear, their relative binding powers, the amounts of residual dust and the nature of the road machinery equipment which is available.

Undoubtedly the order of excellence in road materials, independent of other issues, is trap rock, vitrified brick, limestones, granites, gravels, sandstones and clays. The economic question, however, is not to be ignored, for the nature of the travel, the size of the individual loads and the grades on which the line is to be built demand consideration. Finally, the question of a comparison between high first cost with little subsequent repairs and the low cost of construction, with continual outlay for maintenance is a condition which must be equated to determine the character of the work. Frequently it may be desirable, if not actually necessary, to import material where no stone exists and where it is of inferior quality. It may be necessary—as the author believes it is—in the western districts to utilize the inferior shale by cementing it into brick. These are all elements of individual preference and judgment. A proper selection of local stone will lead to more road building than a reliance upon trap as the sole material.

To guide the road master in his selection there will be found within the pages 610 to 628 a table showing the varieties of surface materials which are available within the several townships, and, so far as possible the places where they may be found. Possibly better locations may be revealed, but the table represents the results of the year's inspection and does not pretend to be complete. So many conditions of topography exist in each township and so varied may be the command of every locality for an improved road that the selection of an available quarry may not always be the best suited for the purposes. It contains, however, sufficient suggestions for most, if not all, of the townships that no apology need be made for its deficiencies in some localities. Location of the site is a matter of judgment.

It is not always certain that the highest grade of road material as judged by the standard tests is the most desirable. Many engineers there are who will be found to have declared it preferable to haul volcanic rock several hundred miles for use on a road in competition with the local stone in order to secure the best surface covering. Such declarations as these the reader must interpret as assuming that the highest type of road is desired that money and machinery can construct. *The volcanic rock should be employed only when the construction of the road is to be of the perfect type, employing rock crushers, screens, steam rollers and sprinkling wagons.* Such a road would be the pleasantest and safest, next to an earth road. In a locality where such an equipment is not possible or feasible, this character of surface will not prove satisfactory. Again, *such a rock covering is required only in regions of very heavy travel or for speedways.* Numerous instances may be cited in support of this, for example, one from Massachusetts—the Nantucket road—which was made partly with a Hudson river trap, which is an extremely good road ballast for heavy wear. But it was found in this case that the road would not stay down. The materials loosened or unraveled because the traffic was insufficient to keep it down, and that, too, notwithstanding an unusual amount of continued rolling. It was finally found necessary to put on limestone screenings, though that rock is far inferior to the matrix which was used. The French District Commissioners also quote in their reports similar experiences where a hard superior rock has been incapable of holding its own when subjected to a light travel only. In Chester county, however, trap covering gives better satisfaction than brick paving, considering everything.

The Best or a Good-Enough Road.—There are two conceptions of roads: 1. The ideal smooth surface, capable of carrying any and every load, in good condition always. 2. The good-enough road that represents a fair degree of improvement and is a compromise between the past and the future. This last can be secured, perfect in all kinds of weather, though it may be difficult to convince the average mind of the fact. *A firm macadamized roadbed, solid and dry in all seasons of the year can be built,* at a moderate cost, without a great revolution in our present methods of construction. It certainly would not require the annual expenditure for repairs that is being wasted under our present unbusiness-like road constructions. We have so long negligently accepted the difficulties of travel during seasons of excessive rain, when traffic is even entirely suspended, that we cannot conceive of a simple remedy such as is offered by the proposed improvement. If, instead of leaving the rock dumped loosely on our winter roads, to be compacted, broken or shifted with each wagon trip, we would simply employ broader tires, or a

heavy roller to consolidate the mass, the solution is at once reached. We have never heretofore made systematic effort to carry the water from our road surface, nor have we made attempt to avert the injury done by frost. The infernal "breakers" are our sole efforts in this direction. Even they fail. Far less have we done in the direction of preventing the decomposition and dissolution to the rock itself by the destructive agency of water.

It is to be hoped that a new era will soon be established in Pennsylvania that will give to her citizens roads which are as durable as those prepared in adjoining States. The material is at hand, the means have always been furnished and the occasion is as urgent and the returns will be as great as are enjoyed by our more progressive neighbors, if they but grasp the opportunities afforded them.

The following table shows the number of miles of road now in common use in the several counties and the coverings used, as announced by the road supervisors to the State Secretary of Agriculture four years ago. The mill tax rate is an estimate of average reports:

POPULATION, AREA AND ROAD MILEAGE OF COUNTIES IN THE WESTERN AND NORTHERN TOPOGRAPHIC DIVISION.

Counties.	Population, 1990.	Area, square miles.	Linear Miles of Roads.*		Miles of Road per Square Mile of Area.	Approximate road mill tax.	Materials Used as per Supervisors' Reports.
			Natural.	Improved.			
Allegheny,	551,959	757	2,571	148	3.4	.2	Sand.
Armstrong,	46,747	612	2,397	140	3.8	.2	Sand.
Beaver,	50,077	452	1,262	11	2.9	.0	Sand.
Bradford,	59,233	1,162	2,444	1,000	2.1	.9	Shale, cobble, slate.
Butler,	55,339	814	1,453	1,119	1.7	.1	Sand, flag.
Cambria,	66,375	666	1,533	113	2.5	.2	Sand, slate, cobble.
Cameron,	7,288	351	213	9	0.6	.0	Sand, cobble.
Clarion,	26,902	572	1,484	212	2.5	.3	Sand.
Clearfield,	89,565	1,130	1,862	152	1.7	.1	Sand, cobble.
Crawford,	45,224	1,066	1,708	865	1.7	.3	Sand, slate.
Elk,	22,239	774	2,456	81	3.4	.1	Cobble, sand.
Erie,	22,074	772	2,074	97	2.5	.1	Sand, lime.
Fayette,	89,004	830	2,095	407	2.5	.5	Sand, gravel.
Forestburg,	8,482	431	2,065	117	4.8	.5	Sand, gravel.
Greene,	28,935	620	1,250	11	2.1	.0	Sand, shale, cobble.
Indiana,	42,175	823	2,290	93	2.7	.1	Sand, shale, flag.
Jefferson,	44,005	646	1,136	50	1.8	.1	Cobble, gravel, boulders.
Lackawanna,	142,088	484	831	115	2.0	.2	Sand, lime, cobble.
Lawrence,	37,517	376	997	70	2.7	.2	Sand, cobble.
Mercer,	55,744	666	1,781	269	2.7	.4	Gravel, shale, blue granite.
Pike,	9,412	631	1,742	120	1.1	.2	Sand, cobble.
Potter,	22,778	1,071	1,271	373	1.1	.3	Gravel, shale.
Somerset,	37,317	1,102	2,454	517	2.2	.4	Sand, cobble.
Susquehanna,	40,093	823	2,454	715	3.4	.3	Gray, blue, cobble.
Tioga,	32,313	1,124	2,299	923	2.0	.8	Sand, cobble.
Township,	46,649	663	1,257	374	2.0	.6	Sand, cobble.
Warren,	21,555	583	1,064	150	1.8	.7	Sand, flag, lime.
Washington,	31,155	583	1,064	150	1.8	.7	Sand, flag, lime.
Westmoreland,	112,819	747	1,235	225	1.6	.3	Sand, slate, cobble.
Wyoming,	15,831	1,046	2,564	301	2.3	.0	Cobble, shale.
Total,	23,331	49,208	9,180	2.5	.....	.....	.....

*Columns marked * are obtained from records in the office of Department of Agriculture of Pennsylvania.

POPULATION, AREA AND ROAD MILEAGE OF COUNTIES IN THE MIDDLE TOPOGRAPHIC DIVISION.

Counties.	Population, 1890.	Area, square miles.	Linear Miles of Roads.*		Miles of Road per Square Mile of Area.	Approximate road mill tax.	Materials Used as per Supervisors' Reports.
			Natural.	Improved.			
Bedford,	28,644	1,003	1,924	264	1.9	0.2	Sand, lime.
Blair,	10,866	490	784	153	1.6	0.2	Sand, lime.
Carbon,	23,866	1,297	654	3	1.5	0.0	Sand, lime, cobble.
Cass,	23,769	1,297	1,356	317	1.5	0.3	Sand, lime, flint.
Columbia,	28,682	457	800	119	1.1	0.1	Sand, lime, mountain stone.
Cum gratia,	36,832	857	723	6	1.0	0.1	Sand, lime, slate.
Fulton,	10,837	442	635	49	1.5	0.1	Sand, slate, lime.
Huntingdon,	35,751	899	1,451	141	1.6	0.1	Sand, flint, lime.
Juniata,	16,655	407	835	157	2.2	0.4	Sand, lime.
Lehigh,	76,631	364	787	24	2.1	0.1	Sand, lime, flint, mountain.
Luverne,	201,203	926	1,604	65	1.7	0.1	Sand, cobble.
Lycoming,	70,575	1,213	1,921	52	1.6	0.1	Sand, slate, shale, mountain.
Mifflin,	19,996	377	563	102	1.5	0.3	Sand, lime.
Monroe,	20,111	595	1,009	76	1.7	0.1	Sand, cobble, lime, granite.
Montour,	13,645	481	14	14	3.4	0.1	Sand, lime.
Northampton,	84,220	323	1,427	25	3.7	0.1	Sand, cobble, lime.
Northumberland,	74,693	462	1,339	102	2.8	0.2	Sand, cobble, flint, mountain.
Schuylkill,	124,183	810	1,680	202	2.9	0.2	Sand, lime, cobble, flint.
Snyder,	17,610	317	1,080	148	3.4	0.4	Sand, lime, cobble, flint.
Sullivan,	11,620	484	790	106	1.6	0.2	Sand, shale, gravel.
Union,	17,820	315	610	68	2.0	0.2	Lime, flint, mountain.
Total,	13,591	21,992	2,342	1.91	.....	.....	.....

*Columns marked * are obtained from records in the office of Department of Agriculture of Pennsylvania.

POPULATION, AREA AND ROAD MILEAGE OF COUNTIES IN THE EASTERN TOPOGRAPHIC DIVISION.

Counties.	Population, 1890.	Area, square miles.	Linear Miles of Roads.*		Miles of Road per Square Mile of Area.	Approximate road bill tax.	Materials Used as per Supervisors' Reports.
			Natural.	Improved.			
Adams,	23,486	531	1,279	178	2.4	3½	Sand, flint, iron, granite.
Berks,	187,327	900	2,953	578	3.3	5 to 7	Sand, lime, shale, granite.
Bucks,	70,615	595	2,107	256	3.3	3 to 4	Sand, cobble, granite.
Chester,	89,377	763	2,370	249	3.0	4	Sand, cobble, flint, lime.
Cumberland,	47,971	554	873	183	1.6	3	Lime, slate.
Dauphin,	96,977	523	984	66	1.8	3	Sand, cobble, mountain.
Delaware,	74,683	195	669	204	3.4	4	Trap, flint, cobble, granite.
Franklin,	61,433	756	1,921	623	2.6	3	Sand, lime.
Lancaster,	149,096	973	2,521	246	2.6	3	Sand, lime, flint, granite.
Lebanon,	48,181	256	567	130	1.6	2	Sand, lime, flint, lime.
Montgomery,	123,290	484	1,696	342	3.5	3½	Sand, slate, cobble, iron.
Perry,	26,276	476	1,007	256	2.1	3	Sand, slate, cobble, iron.
York,	96,459	921	2,922	423	3.1	3	Flint, lime.
Total, .....	.....	8,027	22,298	3,744	3.23	.....	.....

Philadelphia, report 1900, has 1,450 miles of road and streets in use.

SOME REMARKS ON THE DISTRIBUTION OF ROAD BALLAST IN THE SEVERAL COUNTIES ARRANGED ALPHABETICALLY. *

Adams County.—Being almost wholly agricultural, the examination of its surface is very difficult. Its geology is complex and consists essentially of gneiss in the four western townships; limestone of medium grade in Conewago, Union and Oxford townships, and sandstones of various colors in alterations of red or grey. In the balance of the county these sandstones occur in layers. Some are calcareous and some of them are coarse grained. Traversing this central belt and manifested on various hills in the county are dolerite and diorite, which are serviceable for both building and road purposes. There is a great array of these traps poured out on the old Triassic floor. The amount is exceedingly large, and if all that is above the main level of the surface were utilized for road purposes, there would be sufficient supply to cover the roads of the entire State, nine feet wide and six inches thick. The material is of high grade for such purpose and would readily bear the cost of transportation to any portion of the State in competition with the best of its local material. Some localities appear to be favorable for production of road metal. Many are inaccessible to railroad.

Allegheny County.—Its surface contains, in the northern portion of the county, sandstones and shale without any limestone; in the southernmost tier of townships a limestone of good quality is to be obtained.

Armstrong County.—With the exception of the iron-bearing limestone, which occurs midway up the banks of the streams emptying into the Allegheny river, and in the hills in Franklin, Pine and Burrell townships, the rocks which are available for road-building purposes are sandstones and glacial gravel.

Beaver County.—Contains no high grade road-building material with the exception of a black limestone which occurs along the Beaver and Ohio River Valleys.

Bedford County.

Bedford—Limestone.

Broad Top—Fire clay and red shale.

Colerain—Limestone in the valley.

Cumberland Valley—Limestone.

East Providence—Red sandstone.

*The exhibit of road metal and the possibilities of road construction should be of advantage to the residents of the districts who seek definite information regarding the deposits of bedded rocks and the masses of primary rocks suitable for first class roads. The table has been compiled from all sources at hand. The reports of the Second Geological Survey of the State and various other documents have been freely drawn from besides the reports of the Pennsylvania State College School of Mines on "Structural Materials." Personal visits and examination have contributed largely to this table. Fifty-three counties have been traversed, their prominent roads examined and quarries inspected.

East Saint Clair—Excellent shale in the lowlands.

Harrison—Excellent shale in the lowlands.

Hopewell—Excellent shale in the lowlands.

Juniata—Excellent shale in the lowlands.

Liberty—Excellent shale in the lowlands.

Londonderry—Excellent shale in the lowlands.

Monroe—Excellent shale in the lowlands.

Napier—Excellent shale in the lowlands.

Snake Spring—Limestone in the valley.

Southampton—Excellent shale in the lowlands.

South Woodbury—Limestone in the valley.

Union—Excellent shale in the lowlands.

West Providence—Excellent shale in the lowlands.

West Saint Clair—Excellent shale in the lowlands.

Woodbury—Limestone in the valley.

Berks County.—Contains two kinds of gneisses of distinctly stratified schist and syenite. The former furnishes a sandy quartz and a lustrous earth. The syenite weathers to a brownish red clay. The gneiss extends along Perkeomen creek into Hereford township, and southward along the valley between the south base of the South Mountain, and a Triassic sandstone. Some of it is blue and very hard; all of it is very much jointed and closely cleaved. The sandstone is a quartzite, white in color and contains feldspar. It extends along the gneissic hills into Rushcombmanor township. In places it is impure and shaly. The limestone occupy a belt of lowland about three miles wide, extending across the county with the mountain ridges. It varies in color from white to deep black, containing a great deal of organic matter and iron. Most of the limestone is magnesian, hard, flinty, compact and almost crystalline. Lime quarries, from which may be obtained rock waste, are numerous and located centrally in the county and should be able to supply adjoining townships with all that might be desired of a medium grade of road metal. Iron-bearing sandstones occupy the southern portion of the county and furnish fair road surfaces. At various points in Spring, Cumru, Exeter, Douglas and Washington townships along the northern edge of the belt of sandstone, where it comes into contact with the lime, are dike stones in layers having the same traction and dip as that of the sandy rock. The diorite is greenish in color, hard and crystalline, apparently breaking into very small fragments when crushed. This green stone contains a great deal of feldspar and also occurs near the large magnetic iron mines of the district. Boulders cover the region. The hills at Fitztown contain, perhaps, the largest exposure of green stone in the entire county. The distribution of superior road ballast is uncertain. On the other side of the creek is found a very good grade of syenite. South of this point

a fine-grained calcareous conglomerate occurs which would supply good local road covering. The iron mines of the county are numerous and from them should be procured a large quantity of cementing material for the sandstones on the south and the poor road shales on the north.

Blair County.—The ganister mined at Williamsburg is used for the macadamizing of roads about Altoona.

Allegheny—Gray sandy shale in the valley.

Antis—Gray sandy shale in the valley.

Blair—Gray sandy shale in the valley.

Catherine—Limestone.

Frankstown—Red shale, iron ore, limestone.

Freedom—Gray sandy shale in the valley.

Greenfield—Gray sandy shale in the valley.

Huston—Limestone.

Juniata—Gray sandy shale in the valley.

North Woodbury—Limestone.

Snyder—Gray sandy shale in the valley.

Taylor—Limestone.

Tyrone—Limestone.

Woodbury—Limestone, ganister on Piney creek.

Bradford County.—With the exception of LeRoy, Overton, Armenia, Barclay and Monroe townships, suitable road materials may be obtained from the calcareous shales which cover the entire surface. In the townships named as exceptions, the shale is sandy in nature and belongs to the coal measures. Both on account of topography and a poor quality of the clay the road systems of these townships are very poorly developed. At Burlington is an excellent limestone bed of considerable thickness and easily mined.

Bucks County.—With the exception of the townships and their surface named below, the only road stone of any abundance to be found is the various sandstones of the Triassic formation, which are, in the main, unfit for roads, some being calcareous and others conglomeritic. The green stone trap occurring in isolated portions of the county are quite easily accessible and capable of supplying a heavy demand without going too deep in the quarry for the material. Rockhill township has the largest, thickest and longest dike of this material. There is a good supply of trappean material. This should be developed even if the granites are ignored. Microscopic examination does not prove favorable to the sandstones.

Bensalem—Hornblende, gneiss at Oakford; syenite at Willets.

Bristol—Mica-schist, conglomerate, granite at Rockville.

Buckingham—Limestone at Centerville.

Durham—Gneiss, red sandstone, shale, limestone at Durham.

Falls—Mica-schist under the gravel, quartzite, granite.

Haycock—Red sandstone, extensive exposure of trap on the mountain.

Lower Makefield—New red sandstone, gravel, a poor quality of syenite.

Middletown—Mica-schist, yellow to red sandstone, felsite.

Milford—Coarse grey sandstone and trap at Rocky Point.

Rockhill—Red conglomerate, diabase.

Solebury—Grey sandstone, limestone at Center Bridge.

Springfield—Gneiss, red sandstone, shale, limestone at Springtown.

Southampton—Decomposed schist, granite at Feasterville; marble at Neshaminy Creek.

Upper Makefield—Coarse yellow to red sandstone; trap at Brownsburg.

Butler County.—The two northern tiers of townships contain the ferriferous limestone along Slippery Creek Valley, and this is the sole road-building material which is suitable for a hard surface. It is also exposed along Muddy Creek.

Cambria County.—Is very poorly supplied with a road ballast. Its sole reliance is from the clays of the coal measures and the brick locally burned from them.

Carbon County.—This is one of the longest and finest rock sections on exhibitions to geologists in our State.

Cameron County.—No available stone has been found in the accessible regions of Cameron county.

Centre.—This large and important county presents "all the most interesting features of the Palaeozoic geology of the State on a grand scale—a wide expanse of mountain upland, with important coal areas on its top, in the western townships—an uninterrupted Devonian and Silurian valley crossing its middle townships—great anticlinal waves bringing up to the present surface hundreds of square miles of Siluro-Cambrian magnesian limestones, charged with superb deposits of brown hematite iron ore—long parallel symmetrical synclinal ranges of Medina-Oneida mountains separating the limestone valleys—and a labyrinth of these mountains in the south-eastern townships, formed by numerous close rock-waves and faulted in several places." Caverns filled with iron ore, on Sinking Creek, near Egg Hill, in Potter township, prove that the great brown hematite pipe ore deposits of Centre county fill depressions in the limestone which were once roofed like other caverns. The townships along Bald Eagle Creek are alone provided with shale of excellent quality, and a good grade of durable limestone on the east side. The townships between Bald Eagle Mountain and the Seven Mountains must depend upon the magnesian layers of limestone which adjoin the black and dark clay shale, which also makes a fairly satisfactory road

covering. In Rush, Snow Shoe, Burnside and Curtin townships the road material is of poor quality except on the tops of the ridges, where a shale of medium quality is to be had.

Chester County.—Has no lack of trap and gabbro covering comparatively considerable areas. It is of the dolerite variety, though it occasionally resembles syenite. Next in value comes the serpentine which is sufficiently abundant to constitute an important road material in the region known as the "Barren." The limestones which are found in the county are free from magnesia, highly crystalline and blue or white in color. Serpentine is abundant, hard, serviceable and extensively mined. Syenite is not infrequent, occurring as a coarse, crystallized white feldspar and hornblende. Next in the order of merit is the red sandstone, which produces a thin, poor soil, but contains, however, elements which will cement when once rolled. The lowest grade of road materials in the county are the mica-schists and feldspar porphyries. They occupy a large portion of the field and are of doubtful utility for road building. The 125 miles of improved roads and 160 of turnpikes are covered with trap over local shale, or native "hornblende."

Birmingham—Serpentine, limestone.

Caln—Limestone at Gallagherville.

Charlestown—Quartzite, conglomerate and syenite at Charlestown.

East Bradford—Mica-schist, limestone, serpentine.

East Brandywine—Syenite, quartzite near Guthrieville.

East Caln—Limestone at West Whiteland; syenite and dolorite at Downingtown.

East Coventry—Sandstone, gneiss, dolorite in the southwest.

East Fallowfield—Mica-schist.

East Goshen—Mica-schist, serpentine at Goshenville; quartzite near Rocky Hill.

East Marlboro—Gneiss, limestone, serpentine.

East Nantmeal—Feldsparic granite and syenite, dolorite near Marsh P. O.

East Nottingham—Chlorite, schist and serpentine at Elkdale.

East Pikeland—Gravel, quartzite, iron ore at Kimberton.

Easttown—Granite, trap, at Smith's Quarry; syenite.

East Vincent—Sandstone.

East Whiteland—Schists, limestone near Malvern and Warren Tavern.

Elk—Serpentine at Hickory Hill.

Franklin—Gneiss, serpentine and limestone.

Highland—Schist.

Honeybrook—Trap at Cambridge; Limestone at Harmony Hall.

Kennett—Syenite and limestone at Kennett Square.

London Britain—Gneiss, quartzite, granite limestone at Nevins, New Garden.

Londonderry—Schist.

London Grove—Quartzite, limestone at West Grove.

Lower Oxford—Chlorite and schist.

New Garden—Limestone at Cedar Spring and McFarland.

Newlin—Schist, limestone, serpentine near Oak Hall.

New London—Gneiss.

New Coventry—Dolorite, trap, sandstone, red shale at Warwick.

Pennsbury—Gneiss and limestone.

Penn—Iron ore and quartzite.

Pocopson—Gneiss.

Sadsbury—Black gneiss at Greenwood Forge; limestone at Pomeroy.

Schuylkill—Red shale at Phoenixville.

South Coventry—Sandstone, gneiss, dolorite in the southwest.

Thornbury—Syenite, gneiss.

Tredyffrin—Iron ore, serpentine, limestone at Cedar Hall Station.

Upper Oxford—Schist.

Uwchlan—Gneiss, syenite, trap at Windsor.

Valley—Gneiss, quartzite, limestone, near Coatesville.

Wallace—Syenite and conglomerate.

Warwick—Trap at Harmonyville; gabbro at Knauerton.

West Bradford—Mica-schist and limestone near Copesville.

West Brandywine—Conglomerate.

West Caln—Quartzite, limestone, gneiss, syenite at Wagonville.

West Fallowfield—Chlorite and schist.

West Goshen—Schist, serpentine, dolorite in the southwest.

West Marlboro—Mica-schist, limestone near Doe.

West Nantmeal—Quartzite, trap at Perkins; syenite at Loag.

West Nottingham—Mica-schist, iron ore, serpentine.

West Pikeland—Iron ore, feldsparic granite at Chester Springs.

Westtown—Serpentine and trap at Hemphills.

West Vincent—Red sandy shale and syenite at Birchrunville.

West Whiteland—Schists and limestone at Roberts.

Willistown—Schists, limestone and serpentine.

Clarion County.—Is mainly overlaid by glacial gravel, some of which along Mill Creek and Deer Creek and near Jefferson City, is of very high grade. The southern townships, tributary to Redbank Creek, have numerous exposure of the ferriferous limestone, which make a good road-building material. That which is mined at West Freedom shows well under the microscope.

Clearfield County.—It is only along the banks of the Susquehanna and Anderson Creek that any suitable gravel has been found. No

limestones have been identified in the county and its main reliance must be upon imported material or artificial product made from the fire-clays of the coal beds.

Clinton County.—In the northern two-thirds of the county through which the Susquehanna passes, the development of high grade road stone does not seem possible; the roads are sandy and no evidence of good gravel has been discovered. In Eagle, Allison, Dunstable and Pine Creek townships is a copious supply of lime and high grade shales, which make excellent road beds. In Porter, Lamar, Logan and Greene townships are limestones and shale of an inferior quality, although suitable for a fair road surface.

Columbia County.

Beaver—Red shale.

Benton—Green shales and sandy limestones cover the township.

Bloom—Limestone along the river.

Briar Creek—Red shales; impure limestone at Berwick.

Catawissa—Calcareous shales; dark blue limestones.

Center—Decomposed limestone, green shale, glacial moraine.

Conyngham—Sandy fire clays and slates.

Fishing Creek—Grey shales; decomposed limestones.

Franklin—Sandstones.

Greenwood—Red and grey shales; limestone at Emillville.

Hemlock—Shales and iron ore; limestone at Ashlandville.

Jackson—Is entirely covered with poor quality of sandstone.

Locust—Sand.

Madison—Red sandy shales; limestone near Ellis.

Maine—Grey shale; impure limestone along the river.

Mifflin—Shales; blue grey limestones.

Montour—Ferruginous shale; limestone at Rupert.

Mount Pleasant—Red shales, gritty limestones near Moranville.

Orange—Shales, red sandstone and glacial boulders.

Pine—Calcareous shales, green and red.

Scott—High grade limestone, a ferruginous sandstone north of the river.

Sugar Loaf—Red sandstone of poor grade.

Crawford County.—Is overlaid with glacial gravel. Underneath it is a sandstone of a very poor quality. No good road material has been revealed.

Cumberland County.—The famous turnpikes of the central portion of this county are sufficient evidence of the character of the road-building material to be obtained in this county. The limestone is grey to blue; has fine cementing qualities, though a little too granular to be placed among the best of the hard road stones. The iron ores in the banks scattered over the county furnish additional cementing material where desired, and would help to harden the roads in the

shale on the south flank of Blue Mountain. The rocks in the southern tier of townships are gneissic in character, hard but brittle. There is a belt of dolerite trending due north and following the ridge between Silver Spring and Middlesex. There are very extensive limestone quarries in the county and a few places at which granite is mined for building. Rye township has a thick dike revealed at Cove Creek. It is of felsite.

Dauphin County.—Although it is covered with a variety of shales, they are of inferior quality, except at Fishersville, and are, therefore, supplanted for road purposes by the limestone which pass through Swatara and Derry townships, in an easterly direction. The trap, which is in Conewago and Londonderry township, has not been developed, though an abundance of boulders are found on the surface. Near Middleburg, also, is an exposure of gabbro which is accessible, and, of course, satisfactory for road metal.

Delaware County.—The gneiss maintains the same character throughout. It is a hard feldsparic granulite with little mica, but magnetic. The serpentine belt from Lenni to Radnor is quarried in many places. The mineral is far altered.

Aston—Schist, syenite, serpentine and conglomerate.

Bethel—Syenite and conglomerate.

Birmingham—Schist and gneiss.

Chester—Gravel and syenite.

Darby—Gravel.

Haverford—Schist, serpentine, red sandstone.

Edgemont—Schist, syenite, serpentine, trap at Howelville.

Lower Chichester—Syenite on Stony Run and at Linnwood Mills.

Marple—Schist, syenite, serpentine trap.

Middletown—Schist, granite, syenite, serpentine.

Nether Providence—Gneiss, gravel, at Avondale.

Newtown—Mica-schist, syenite and serpentine.

Radnor—Conglomerate, serpentine, limestone, syenite.

Ridley—Gravel.

Springfield—Trap at Marple; gravel at Morton.

Thornbury—Syenite, serpentine; trap at Glen Mills.

Tinicum—Aluvium.

Upper Chichester—Syenite near the creek.

Upper Darby—Gneiss, trap, gravel at Lansdowne.

Upper Providence—Schist, syenite, serpentine, trap.

Etik County.—Along the Little Toby Valley and on Pistner Hill is found a very good sandy shale, making an excellent road material, above which is a limestone suitable for road surface of medium grade.

Erie County.—Has no good natural road stones, but possesses along the Lake Erie front a wide range of shales from which the roads furnish excellent driving material. These sandy materials, with the

shingle along the beach, are the sole dependence of the county. The roads leading into the county seat are occasionally gravelled for a central driveway, about fifteen feet wide.

Fayette County.—Two ridges which traverse Saltlick, Springfield, Stewart and Henry Clay townships contain a medium grade of shale of good cementing quality, though not very durable. Red Stone, Washington and Tyrone townships have another shale quite close to the railroad which would make suitable road covering. Otherwise, the county must depend upon the constant supervision to secure the good natural roads which might be possible in the early spring.

Forest County.—Is, unfortunately, like the other northwestern counties, in possessing no excellent road-making materials near the surface. The banks of the streams traversing it would supply gravel and shale, a mixture of which should be compacted into a good surface. The gravel of course must be that taken from the upper elevations of the banks.

Franklin County.—Contains a wide range of rocks for road-making use. The several turnpikes, which have had nearly a century of use, testify to the serviceability of the native material. The red schists on the east make a strong road surface, as do the limestones of the Cumberland Valley. Both rocks are, however, too brittle for the best service under heavy travel. The best remedy for the dusty condition of these roads would be oil sprinkling. This would be found cheaper and more durable than the prevailing practice of replenishment. The breccias of South Mountain should have further trial for top dressing than that given them unrolled.

Fulton County.—The sole supply of Fulton county for road material comes from Big Cove Creek, though in Pigeon Cove is limestone of better quality. The shale in the middle tier of townships is of lower quality than that which occurs in Wells township.

Greene.—The rolling topography of its surface gives great difficulty in the solution of the problem of improved roads. The pioneer routes along the creeks have been preserved, and construction has been confined to shaping the road surface to an arch. But no rock is available which would make a high-grade ballast. The Fishpot limestone is a very good road metal. It should be more extensively used. A large exposure occurs near Brownsville.

Huntingdon County.—Possesses without doubt the widest range of road materials, though they are all of the medium to inferior grades. The best limestone for road metal is that which follows the phosphate belt in Aughwick Valley and along the Huntingdon and Broad Top Railroad. The shales included between these lines furnish pleasant travel and are identical with, though not so hard as those which

furnish the famous Delaware river drive. Near Nossville and Shade Gap are exposures of good lime, while in Franklin and Warriors' Mark is a hard magnesian limestone making a fair road surface.

Indiana County.—The several anticlinal folds in the rocks have not seriously affected the subterranean topography enough to bring to the surface any road-making materials of high grade. Its surface is composed of soft, decomposable sandstones and shale, out of which little suitable material can be had for permanent roadways without treatment. A large number of brick-making establishments are producing good road pavements that probably will serve some day the highway engineer. The Upper Freeport limestone, in a bed less than ten feet thick, is exposed in several convenient places. Numerous other beds occur, but they are thinner than the Freeport.

Jefferson County.—Has a surface of sandstone and coal measures, with very little prospect for road ballast of high grade.

Juniata County.

Beale—Limestone at Academia.

Delaware—Limestone at East Salem.

Fayette—Red shale and limestone at Oakdale Mills.

Fermanagh—Flint at the Narrows; iron ore and limestone at Banks.

Greenwood—Shale.

Lack—Shales and limestone at Peru Mills.

Milford—Limestone at Patterson.

Monroe—Shale and limestone near Richfield.

Spruce Hill—Shale in the valley.

Susquehanna—Shale.

Turbett—A little shale and limestone.

Tuscarora—Shales and limestone at Reed's Gap and Honey Grove.

Walker—Limestone and red shales at Mexico.

Lackawanna County.—Is covered essentially with sandstone except along the valley of the Lackawanna River, but even here the road-making materials are scarce.

Lancaster County.—The dike stones are of excellent quality and are good for roads which are the seat of heavy traffic. They appear to be conveniently located. The pyroxenite belt, six miles long, is, perhaps, the most extensive field for medium grade of road metal. The serpentine is abundant but rather soft.

Bart—Trap at Georgetown.

Brecknock—Red sandstone.

Caernarvon—Quartzite, limestone, schist, trap on Turkey Hill.

Clay—Limestone and red sandstone at Ephrata.

Colerain—Fissile schists.

Conestoga—Limestone and trap at Safe Harbor and Millersville.

Conoy—Trap, Keller's Quarry; dolorite, Bridgeville; limestone, Haldeman quarry.

Drumore—Gneiss at Penrose Dam; a small dike of dolorite.

Earl—Red sandstone, limestone, trap at Pleasant View.

East Cocalico—Sandstone and a little trap near Reamestown.

East Donegal—Limestone and trap at Mt. Joy borough and Marietta.

East Earl—Conglomerate, blue lime at Weaver's Mills.

East Hempfield—Limestone, trap, on Chestnut Hill.

East Lampeter—Limestone.

Eden—Limestone, mica-schist, dolorite at Quarryville; gneiss at Myres.

Elizabeth—Limestone and red sandstone, trap at Brickerville.

Ephrata—Limestone.

Fulton—Chlorite schists; thick dike at Goshen.

Lancaster—Limestone.

Leacock—Limestone and slate.

Little Britain—Mica-schist in blocks or flags.

Manheim—Limestone.

Martic—Limestone, gneiss on Tocquau Creek.

Paradise—Limestone and gneiss; trap in the southeast corner.

Mount Joy—Red sandstone, limestone at Milton Grove, in Upper Bainbridge.

Penn—Red sandstone and limestone at Manheim.

Pequea—Limestone, slate and schists.

Providence—Ferruginous, mica-schist, limestone at New Providence.

Rapho—Equal halves of sandstone and limestone.

Sadsbury—Micaceous quartzite, slate, limestone on Valley Creek.

Salisbury—Trap at Spring Garden, Peter's Creek and at Bellevue.

Strasburg—Limestone.

Upper Leacock—Limestone.

Warwick—Black limestone at Lititz.

West Cocalico—Trap at Reinholdsville; lime at Schoneck.

West Donegal—Trap at Newville; triassic sandstone, limestone at Reams.

West Earl—Limestone.

West Hempfield—Limestone, mica-schist at Mountville.

West Lampeter—Limestone and slate.

Lawrence County.—The surface is essentially sandstones and conglomerates, with a little shale of good quality near Fayetteville, in Wilmington township and New Bedford, in Pulaski township. The iron-bearing limestone outcrop midway between the flat tableland of the bottom and the valleys.

Lebanon County.—This county is well supplied with satisfactory road metal for macadamizing. It has a limestone of good quality adjoining the shale which passes through Londonderry, Annville, Jackson and North Lebanon. The shales in the central belt of the county are of poor quality to make good dry weather roads; those which have been drained on the sides are often excellent roadways during the fall and winter. The trap occurring near Jonestown is capable of supplying abundant material for improving the important roads of the county, and that which occurs near Coalbrook is sufficiently large and accessible to the railroad to furnish an industry for adjoining districts. It is softer and more readily decomposed than that which occurs in the extreme southeastern portion of the State.

Lehigh County.

Hanover—Shale and slate.

Heidelberg—Shale and slate.

Lower Macungie—Syenite and limestone.

Lower Milford—Red sandstone and syenite.

Lowhill—Shale and slate.

Lynn—Shale and slate.

North Whitehall—Shale and limestone.

Salisbury—Syenite, quartzite and limestone.

South Whitehall—Limestone.

Upper Macungie—Limestone and shale.

Upper Milford—Shale and slate.

Upper Saucon—Red sandstone, syenite and limestone.

Washington—Shale and slate.

Weisenburg—Shale and slate.

Whitehall—Shale and slate.

Luzerne County.—From the point of view of the road maker, this county is not copiously supplied with durable rock. The calcareous shales about Nescopeck and in Huntingdon are the best that is afforded. It is hardly worth while to consider the conglomerates, or the Catskill sandstones north of the river. The materials are prevailingly low in value. They quickly grind to powder. In default of better ballast, the county must rely upon the shales. In the mining communities the roads ought to be dressed with imported screenings from along the Delaware river.

Lycoming county.

Anthony—Shales along Muncy creek; red sandstone on North mountain.

Armstrong—Black marble along the mosquito and red sandstones.

Bastress—A poor quality of soft red sandstone.

Brady—Limestones and shales.

Brown—Red sandstone in the valley; fire clay on the hill.

Cascade—Red sandstone in the valley.

Clinton—Iron, shales and limestone at Clintonville.

Cogan House—Red sandstone in the valley.

Cummings—Red sandstone in the valley.

Eldred—Shale and red sandstone.

Fairfield—Shale and red sandstone.

Franklin—Gray shale.

Hepburn—Shale and red sandstone.

Jackson—Red sandstone in the valleys.

Jordan—Shale.

Lewis—Red sandstone in the valleys.

Limestone—Limestone at Jamestown.

Loyalsock—Shale, red sandstone and limestone.

Lycoming—Shales along Muncy creek; red sandstone on North mountain.

McHenry—Red sandstone in the valleys; fine clay on the hill.

McIntyre—Red sandstone in the valleys; fine clay on the hill.

Mifflin—Red sandstone along Hepburn and Larrys creeks.

Moreland—Gray shale.

Muncy Creek—Shale at Clairstown; limestone at Muncy.

Muncy—Shale and red sandstone.

Nippenose—Red sandy shale and black slate at Fort Antes.

Old Lycoming—Shale, red sandstone and limestone on Pine creek.

Penn—Gray sandstone and limestone at Pennsville.

Piatt—Shale, red sandstone and limestone on Penn creek.

Pine—Red sandstone along the valley; fire clay on the hill.

Plunkett Creek—Red sandstone along the valleys; fire clay on the hill.

Porter—Shale, red sandstone and limestone on Pine creek.

Shrewsbury—Shale and red sandstone.

Susquehanna—Iron, shale and limestone.

Upper Fairfield—Shale and red sandstone.

Washington—Red shales and limestone at Elinsport.

Watson—Red sandstone along Hepburn and Pine creeks.

Wolf—Shale and red sandstone.

Woodward—Shale, red sandstone and limestone on Pine creek.

McKean County.—Is overlaid with gravel covering and sandstone of no value whatever for road purposes. No natural material has been revealed with the requisites for suitable road covering. The sandstone on the surface is very poor for road dressing. The county has a high elevation above the sea. A densely wooded county.

Mercer County.—Only in Pike, Liberty and Jackson townships does there occur road material of even moderate grade of dura-

bility. The balance of the county is devoid of suitable road ballast which is immediately accessible at the surface. Drift covers much of the ferriferous limestone, which, however, is mined at various places.

Mifflin County.

Armagh—Limestone.

Brown—Limestone.

Decatur—Shale at Wagoner; limestone near Decatur.

Derry—Limestone at Logan and Lewistown.

Granville—Limestone.

Menno—Limestone.

Oliver—Limestone.

Union—Limestone.

Wayne—Limestone at Atkinson's Mills; poor shale in the valley.

Monroe County.—Coolbank, Tobyhanna and Tunkhannock are totally devoid of natural road material. The eastern tier of townships possess high grade limestone.

Montgomery County.—This county is, in the main, overlaid by a succession of sandstone layers of various colors, properties which are unsuitable for road making without admixture of cementing material. Norristown uses imported trap rock from Birdsboro, ignoring the local supply. A ridge of dike stone occurring near Green lake and at Sumneytown is quite thick. Another isolated hill of gabbro occurs near the Hill postoffice. With these exceptions, only the townships named below contain road metal of any considerable value. The red shales are unfit for use on main roads but would cover ways of small traffic. The sandstones may be dismissed as unserviceable for first class roads. They grind to powder. The conglomerates seem a little stronger but were not closely examined. The diorite should be exploited. There is an abundance at Conshohocken.

Abington—Mica-schist over limestone; syenite in many places.

Cheltenham—Quartzite, iron ore, granite.

Lower Merion—Gneiss, serpentine, dolorite.

Moreland—Conglomerate, mica-schist, felsite, limestone is said to exist at Somerton.

Plymouth—Quartzite, limestone along the river.

Springfield—Gneiss, limestone, syenite.

Upper Dublin—Quartzite, granite at Gresherton; limestone at Fitzwatertown.

Upper Merion—Slate, limestone, green stone trap.

Whitemarsh—Iron ore, limestone, serpentine at Lafayette; gabbro at Conshohocken.

Montour County.—This small county is almost exclusively overlaid by a grade of red calcareous shales which furnish excellent

road surface. The county as a whole has a fine road system. There is considerable iron in the southern portion of the county and also some extensive quarries of high grade limestone lined along the ridges, as well as at Washingtonville.

Northampton County.—The serpentine of this county is too much decomposed for use on roads. It is like soapstone.

Allen—Limestone and shale.

Bethlehem—Limestone and syenite.

East Allen—Limestone and slate.

Forks—Limestone and syenite.

Hanover—Limestone and syenite.

Lehigh—Shale and slate.

Lower Mount Bethel—Limestone and shale.

Lower Nazareth—Shale and slate.

Lower Saucon—Shale and slate.

Moore—Shale and slate.

Palmer—Limestone.

Plainfield—Shale and slate.

Upper Mount Bethel—Shale and slate.

Upper Nazareth—Shale and slate.

Washington—Shale and slate.

Williams—Shale and slate.

Northumberland County.—Numerous quarries are opened on the Helderberg limestone, whose outcrop is indicated on the topographic map by heavy dark lines.

Delaware—Dark grey limestone; red shale; otherwise sandstone.

Jackson—Conglomerates and red shale.

Chillisquaque—Decomposed limestone; red shale near Montandon.

Jordan—Red shales; impure black limestones.

Lewis—A thick bed of dark shelly limestone of high grade; black shale.

Lower Augusta—Extensive thick beds of olive gray shales and limestones.

Point—Gray, hard sandstone and flint; limestone crossing it.

Rush—Calcareous shales; ferruginous sandstones.

Shamokin—Calcareous shales; ferruginous sandstones.

Turbot—Limestone on the ridge; chert in the valley.

Upper Augusta—Mainly sand and sandy shales.

Upper Mahanoy—Sandstones, red shale, black lime.

Perry County.—Is the typical unit of the middle district with a complicated structure that offers a great variety of rock formations on the surface.

Buffalo—Chert at Half Fall and Mt. Olive; gray shales, poor limestones.

Carroll—Limestone at Sterrett and Falling Spring; shales at Marysville; iron ore at Bloomfield.

Greenwood—Iron ore, shales at Kings Mill; limestone at Millers-town.

Howe—Shales at Newport.

Jackson—Shales at Bistline; limestone at Blain.

Juniata—Shales at Saville and along the Buffalo.

Liverpool—Shales at Barger; limestone at Pfoutz.

Madison—Shales and limestone at Center Mills.

Miller—Black shale, iron at Pine Grove; limestone at Dicks.

Oliver—Shale at Duncannon and limestone.

Penn—Sandstone along Losh Run; trap in the Cove.

Rye—Iron shale on Blue mountain; trap on Iron Stone ridge.

Saville—Shales in Raccoon and on Buffalo.

Spring—Limestone at Elliottsburg; flint and shale.

Toboyne—Poor shale at Concord.

Tuscarora—Iron shale near Millerstown.

Tyrone—Limestone at Green Park; poor shale.

Watts—Iron shales at Girtys Notch.

Wheatfield—Shale on Dicks Hill; sandstone near Dellville.

Pike County.—The townships flanking the Delaware river alone have natural road making material which is easily procured. Covered roads through Lehman, Delaware, Dingman, Milford and Westfall townships affords pleasant traveling in the State during the summer season. The covering is shale, sufficiently sandy to be compact and containing enough lime to bind well with a moderate degree of moisture. The river road built on it is a pleasant driveway. Naturally the sandy soil supports heavy timber. Ninety per cent. of its area is wooded.

Potter County.—Overlaid by glacial gravel, the banks of the numerous ramifying creeks contain soft shale, furnishing a fair road surface but not a durable one. It is poorly supplied with road stone of even mediocre quality. It is a densely wooded territory.

Schuylkill County.—This county is very unfortunate in not possessing road material of a superior quality, being the richest county in anthracite coal and over which a great deal of heavy hauling is done. The surface is corrugated with ten anti-clinal rock rolls, making the solution of the engineering problem an equally difficult one. The Taxpayers' Association of this county however is largely aiding in the improvement of roads of the region. Over 250 miles have been surfaced, the levy of road taxes have been abolished and excellent roads have been obtained at almost no expense to them.

selves. In some townships the tax levy has been reduced from 10 to 3 mills by making their highways permanent. The townships of Cass, Hazle, Schuylkill, East Norwegian, Rahn, West Mahanoy, Foster, Mahanoy and New Castle have utilized the shale and the local cementing material for covering and compacting their roadways.

Snyder County.—The fossiliferous limestone along South mountain is hard, and being rich in iron affords excellent material.

Beaver—Excellent shale and limestone.

Center—Excellent shale and limestone.

Chapman—Excellent shale and limestone.

Jackson—Excellent shale and limestone.

Middle Creek—Excellent shale and limestone.

Monroe—Excellent shale and limestone.

Penn—Red shale and limestone.

Perry—Excellent shale and limestone.

Washington—Excellent shale and limestone.

West Beaver—Excellent shale and limestone.

West Perry—Red shale and limestone.

Somerset County.—Overlaid by the clays of the coal measures, with the exception of the townships of Allegheny, Northampton and Greenville, the natural road ballast of the county is essentially sandy clays and a red limestone of the Ligonier valley. This limestone is dark in color, tough and hard except in a few localities on the east where it is brittle, and contains considerable clay. This limestone is quarried in numerous places for use in the blast furnaces. Though it occurs persistently under one of the coal seams of the county, it has been traced very carefully and cannot therefore be located on a map or by description. It is an important geological horizon and there is no doubt but that a vigorous search would reveal its outcrop. For enriching the agricultural soils, as well as covering the roads, it would seem desirable that the county authorities would institute an investigation in this direction. The roads of the county furnish comfortable traveling only during the dry season.

Sullivan County.—Is poorly supplied with roads which can afford pleasant or safe traveling during the early portion of the year. Its sole reliance has been sandstone, which, unfortunately, has a low cementing quality. Along Muncy and Loyalsock creeks the sandstone is of better quality. It is very heavily wooded.

Susquehanna County.—With the exception of the lowlands on either side of the Susquehanna river and its tributaries, the surface is entirely one of a light red and gray sandstone, most of which being of poor cementing quality. Boulders of calcareous rocks from which the farm lime is made are unsound for road metal.

Tioga County.—As may be expected, the road system of this county

avoids the white, hard sandstone ridges and is confined to the shale lowlands. The shale is of the same variety as furnishes a good road surface in the eastern portion of the State and possesses very similar qualities for a covering. The travel over the roads being light, it is difficult to judge from inspection of the quality of the surface for heavy traffic. The shale contains a very large percentage of lime; indeed, is more nearly limestone than a clay.

Union County.—The western portion of this county is composed of sandy hills and the eastern and southern of fertile valleys in a road shale with a few small exposures of limestone at Wisetown, Mifflinburg and Lewisburg.

Venango County.—Is covered with shales—mainly of varying qualities, and glacial gravel. Some excellent roads are laid along the river and give satisfaction, even with the heavy travel to which some of them are subjected. The mountain limestone at Centerville is the best native material.

Warren County.—The southernmost limit of the glacial moraine passes through this county, leaving drift and gravel which is serviceable for roads, and the conglomerates in the southern half, which, however, does not make good road surface. The shales immediately under it make good brick and furnish a good cement for the gravel.

Washington County.—The erosion of the elements has produced a topography which is remarkable and particularly troublesome to the highway engineer. The hills are round knobs, with water courses surrounding them, cutting deeply through the formations and exposing a great range of rocks, several of which furnish good building material. The limestones, notably, are good.

Wayne County.—No county in the State is so thoroughly covered with but one formation as is this one, which is overlaid by the pink and gray shaly sandstones of the Catskill formation. The roads traverse it in every direction. The surface is quite uniform in elevation. At the base of North Mountain is a good calcareous breccia, quite suitable for road veneering.

Westmoreland County.—Like Fayette county, is overlaid by the coal measures with their sands and fire clays, and little road metal of superior quality has been found. The Ligonier limestone is sufficient in quantity to supply all local needs. It is found in the hollows on both sides of the valley on Chestnut Ridge and Laurel Ridge. It is siliceous and impure. That at Red Stone is quite thick and strong.

Wyoming County.—No high grade road ballast has been discovered in this county. The most of the road surface being sandy except in Braintrim and Meshoppen townships, where shale prevails. The traffic in the county is not heavy and doubtless the natural materials which are available suffice for the purpose.

York County.—This county possesses a great variety of road building materials. Poor mica-schists extent in a central belt from the Maryland line to the northeast. Green stone traps are abundantly exhibited on the surface in the northern portion of the county; phyllite and slates are found in Peach Bottom, Codorus, Springfield, York and Windsor townships. This material is useless for permanent road construction. The marble along the Hanover Short Line is not strong for road purposes but is of very fine crystalline building material. The townships north of that railroad have red shales and sandstone in abundance, with iron ore in various places and extensive crops of trap. Southeast of the railroad are slates, schists and quartzites in rapid successions of layers. From the point of view of road building, those granite rocks are generally of inferior grade. They are very brittle and excessively micaceous. The great accumulations of trap whose fitness for road making is amply proved, lie so conveniently to rail that the other sources need little consideration. Pyroxenite occurs at Bryansville. At New Park and Fawn Grove is a large exposure of good road metal which may be diabase.

THE INFLUENCES OF TOPOGRAPHY UPON ROAD CONSTRUCTION.

The interdependence of the road metal to be employed on a road surface and the engineering phases of the problem is undoubted. The topography of the county to be traversed is related to the geology of the country and the nature of its underlying formations. The grades and drainage of the foundation depends on the character of the surface material and the method of treating the covering is entirely dependent on the character of the road stones. The construction of a substantial road will therefore be considered only so far as it is related to the local supply of the district of superior or inferior stone.

Topography and the Formations. For the purposes of this paper the area of the State was divided into three topographical districts, with the statement that the nature of the geological formations near the surface determined not only the character and amount of available road metal but also the configuration of the surface. From what has been stated, it is easily seen why the topography of

the northwestern district should reveal essentially a flat tableland with a sandstone cap, sculptured by the rivers in various directions whose banks reveal in their terraces the difference in the resistance of the soft shale and the hard sandstone to the action of the atmospheric elements. So, too, in the middle district, the topography consists of a series of broken parallel ridges of sandstone with water courses following the low lands along the lines of the softer shales and limestones. In the eastern district, to a large degree, the water courses still follow the softer rocks though the geology there is too complex to receive detailed attention in its bearing upon the topography at this time. The most perplexing surface in the State is that presented in Greene and Washington counties.

Sandstones everywhere are on the elevated lands and in so much as their waste furnishes a poor soil for vegetation, but a good one for timber, the regions occupied by them are usually densely wooded and only sparsely cleared for cultivation. There is, however, small occasion for important roads over sandstone regions. Again, the material itself furnishes, as we have seen, a very poor basis for natural road covering and such highways are built through their district are either endured in their natural state or else maintained in proper condition at a very high expense. The road system of Tioga, Lycoming, McKean, Elk and other counties, furnish good illustration of the question in point.

Topography and Alignment. Along the valleys the roads are laid on a better foundation and may receive locally a covering of good stone. They naturally follow the lines of the valleys, intersecting highly cultivated fields. Tables, pages 608 and 609, show the aggregate length of roads in the several counties, and also the population of the same regions. Reducing the number of miles of road to a unit of a square mile in area or to the thousand of population, we will again notice that the roads are most abundant in the more fertile agricultural regions. As has been noted under this table, the cities have been omitted from the discussion and the tabulation. This paper is concerned especially with the country districts of the State, and not with the municipalities which enjoy a sufficiently comprehensive administration of highways without reference to the supply of material or the means of procuring the same by State aid. The farmers in the valleys, however, must have access to their shipping points and communication with the occupants in neighboring valleys, and roads of greater or less importance must necessarily be constructed across the undesirable sand ridges. It is along these lines that good roads are especially difficult.

Topography and Grades. The topography, therefore, imposes problems upon the engineers which are by no means simple. The roads should be planned with reference to the slope of the hills as well as

to neighborhood conveniences, and if it is not desirable to level down the ridges for the width of the traveling way or if the road must be the shortest possible line, the question of grade becomes a serious one. Particularly is this true if these local ways are afterwards to be made portions of the main through routes.

When a road system is to be established, one under State aid, contemplating important arteries of communication across several counties, the topography cannot be ignored and the first work to be undertaken requires familiarity with the elevation of the ground and the distances between the fixed points of the lines. Good maps will be required. The cost of the survey across the territory in the construction of such maps may be high, but the saving in the matter of the roads judiciously laid upon such a map will more than repay in a very short time the expense. Heavy grades may be avoided by even a slight change in the position of parts of the road. Steep grades are also surmountable as, *vide* the National Road in Maryland, over hilly districts, like our middle topographic district. Poor foundation beds may be avoided from the knowledge of the surface rocks. Money is largely wasted if these two elements in road construction are not guarded against. Some writer has ascertained by actual computation that the taxes upon products unnecessarily laid upon a traveler over a heavy grade arising from the injudicious placement of highways, amounts to as much as one-fourth of the total cost of wagon transportation over such roads. The question of improved road construction is then as much one of engineering as of geology. The reduction of the grade of the road profile is expeditiously accomplished when the material removed from the summit is filled into the valley. The cost of the haul and of spreading may be compensated for by the value of the road rock recovered. For every hill is but a mass of hard rock thinly clad with a layer of soil. Rock is therefore to be had in plenty with each hill summit reduced along the road line.

The Engineering Phases. The engineering phases will herein be considered only so far as they affect, or are affected by, the nature of the road surfacing materials. The study of the history of the European roads clearly shows that their construction depends upon the very accurate application of a large body of knowledge which has been obtained either by costly practical tests or by the cheaper laboratory experiments. The only short way to the end is by the institution of a system of surveys and reports with appropriate maps by which our road masters may as quickly as possible be put in possession of the required knowledge as to the nature, locality and mode of treatment of the substances available for use. Herein is found what is perhaps the strongest of the many arguments for the prosecution of the topographic work of the United States geological

survey which is now in progress over the eastern portion of Pennsylvania as well as in other States. It is possible to obtain now, large printed sheets revealing the topographic features and contour lines of extended districts at a very low cost from the Department in Washington. These will furnish the desired information of elevations and distances between points included upon the maps. The easiest grade and shortest line are always sought.

Steep grades impose a serious burden upon road construction by furnishing an opportunity for the rains and freshets in flowing down their course to cause torrential destruction over the surface of the roadbed. The effect of the inclination is also to burden the animals in hauling the load up, or in preventing the rapid descent of the wagon down the incline.

The ideal road should have such an easy grade that a brake will not have to be applied in going down nor will the horses have to hold back. This would indicate a grade of one foot rise in 20 feet of distance as the maximum that is safe or wise, and a minimum of six inches rise in a hundred feet of distance. It is true that spurs and ridges must be surmounted, but it is also true that there is a limiting grade beyond which it is not only unsafe but impossible to go, in planning for grade to an important way. For a continuous trot the grade should not exceed one foot in thirty-six on a smooth road. It is dangerous to attempt to descend at a trot over grades exceeding one in twenty, and horses must be well checked and well held if trotted on one in thirty, but down one in forty, brakes need not be applied. Horses cannot for long, trot up a grade of over one in twenty-two.

The mean tractive force of an animal is about one-fifth of its weight. It can be demonstrated that the resistance which is offered by the weight of a load to being pulled up an incline increases with the angle of the slope. To overcome this resistance it will be necessary for the horse to exert a power at least equal to that amount. Should the slope have one foot of rise in a hundred the pull is 1-100 of the weight; that is, a horse must exert a pull of 20 pounds to move a short ton up this incline (having no regard for the moment to the nature of the road surface); on a pitch of one in ten, the tug at the straps must be at least 200 pounds to raise the ton. On the latter grade, therefore, with a perfect road surface, a normal horse would be incapable of raising a ton-load or of holding back against it on the descent, without serious injury to the surface or without over exertion. The maximum or the minimum grade of the road for safety is, therefore, established by the possibilities of the power employed in hauling. On an excessive slope, either the load must be reduced, whether going up or down, or the number of horses increased.

The grade is influenced by the nature of the road surface, which furnishes a limit to the pitch of the road, according to its resistance to traction. A sandy surface offers so high a resistance that on almost any pitch it would be impossible for a horse to pull a load on the level. On a macadamized surface the resistance would be so slight as to hardly reduce the load which a single animal could haul without extra exertion up a grade. For ascending, therefore, a sandy surface should have a flatter grade for convenient travel than a macadamized surface should have. On the descent, a loose sand surface would assist the animal and the brake to prevent a runaway, while on the other hand, on a steep smooth surface a horse must exert an increased effort against the load. Roughly speaking, therefore, a road surface should be smooth at the time of ascent and rough at the time of descent for the best results.

Though both these conditions are impossible to attain simultaneously, engineering practice has decided that the grades should be flatter as the road surface is more perfect. The macadamized road should have a grade not steeper than one in twenty and below this as much as is possible. The horse can haul an ordinary load up this incline without assistance. In important localities, first class macadamized roads should not be steeper than one in thirty; a grade of one in fifty is not too steep for continuous trotting gait, under a standard load on a well paved roadway. Below is given a table showing the number of pounds of tractive force required to move a one ton load at an ordinary walking pace over a dead level surface composed of the materials indicated. It was taken from Bulletin No. 20 of the United States Office of Road Inquiry.

Kind of Road.	Tractive Force.
	Pounds.
Loose sand (experimental),	320
Best gravel (park road),	51
Best clay,	98
Best macadem,	38
Poor block pavement,	42
Cobblestone,	54
Poor asphalt,	26

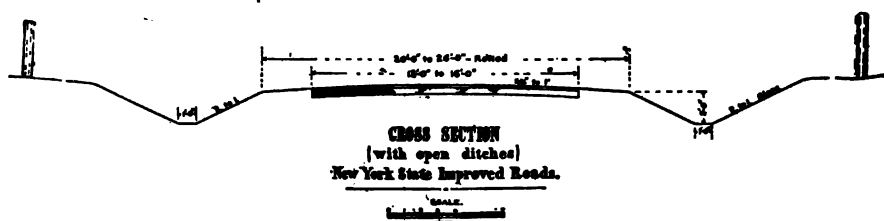
The accompanying table shows the tractive force which is necessary to pull a one ton vehicle over the best macadamized surface of various grades and the equivalent in lengths of each mile of grade in miles of level road.

Rate of Inclination.		Angle with the level.	Tractive force.	Equivalent length of level road in miles.
Level.		° ' "	Pounds.	
1 in 500,	0	00 00	38	1.00
1 in 100,	0	6 53	42	1.10
1 in 80,	0	24 23	58	1.53
1 in 60,	0	43 58	63	1.66
1 in 50,	0	57 18	71	1.87
1 in 40,	1	08 16	78	2.06
1 in 30,	1	26 57	88	2.30
1 in 25,	1	54 37	104	2.73
1 in 20,	2	17 26	118	3.10
1 in 15,	2	51 21	138	3.63
1 in 10,	3	48 51	171	4.60
1 in 5,	5	42 58	238	6.36

Grades and the Rainfall. As the scouring action of freshets flowing over the surface increases with the inclination of descent, it is important to reduce the grade to a minimum whether side drains are built along the traveled way or not. The softer the stones used on the surface the more important becomes the necessity for the diminished grade.

ROAD CONSTRUCTION.

The cross section of the road should be such that the waters will be rapidly carried to the side drains. A crown is therefore built at the centre, the amount depending upon the grade of the road. That which is most desirable below grades of four per cent. (four feet of rise to one hundred feet of distance) is four inches; on grades exceeding four per cent. the height of the crown at the centre should be six inches greater than at the sides. An excessive crown tends to throw all the traffic in one line, and most of the wear would be at the centre, where ruts would soon form. This would defeat the very object of the crown, which is to drain the water promptly to the sides. The less the crown the better satisfaction will it give. Below are two illustrations showing a transverse contour of important roads, the first taken from the report of the State Engineer of New York and the second from the Standard Construction of Massachusetts Engineering Department.



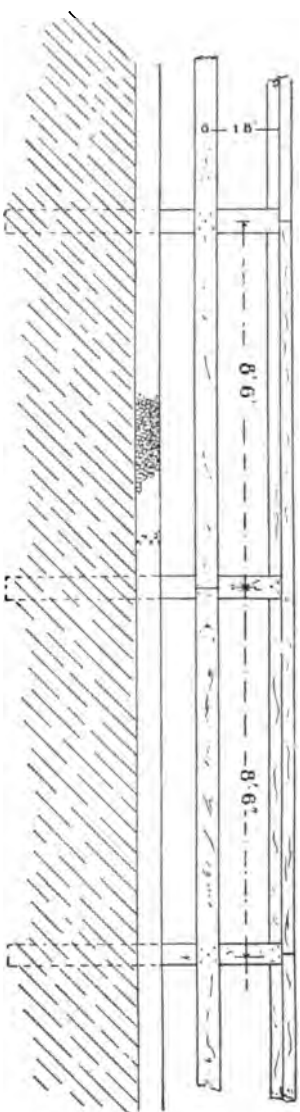
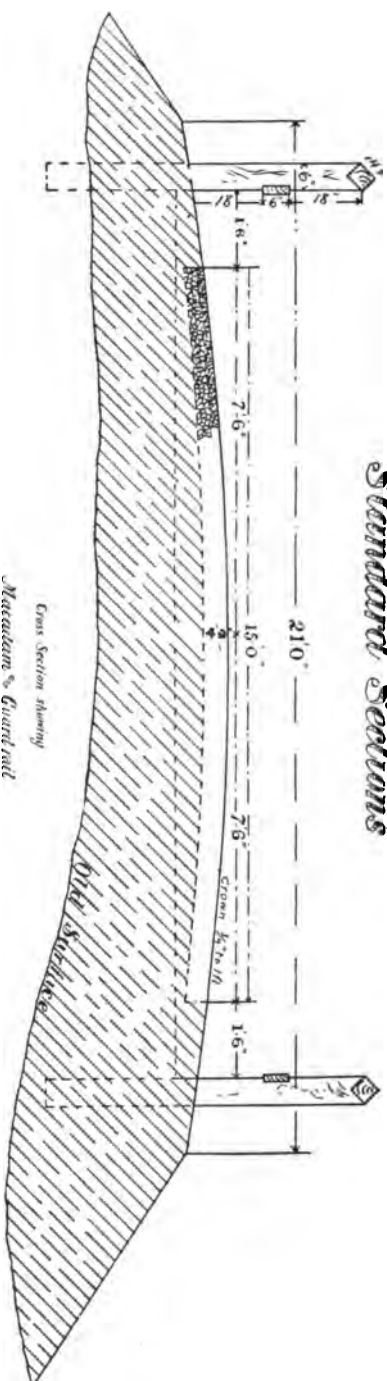
The transverse contour of a vitrified brick pavement would have a total rise not exceeding 1-40. On a gravel road the arching is flat, the rise is 1-30.

The width of the roads to accommodate travel should afford a central roadway, shoulders, ditches and, possibly, a side walk. Confining our attention to the stone roadway proper, it rarely need be more than 12 feet, and in many cases 8 or 10 feet will be sufficient. Where the travel is constant in both directions the stone way should perhaps be 15 feet. The tendency to a single track is so strong that even on a wide roadbed the travelers would confine their route to a very small limit. An examination of the sixteen-foot stoned roads in Massachusetts shows that 11 feet is the mean width of travel, and a width of 12 feet would be ample in the vicinity of the larger towns. In Maryland the width commonly traveled in Carroll, Allegheny and Baltimore counties is between 8 and 10 feet. The writer favors a 7 or 8 foot road as sufficient provided the macadamizing be carefully made. The addition at the sides for shoulders of a few feet in width of good gravel would give a turnout when desired, if firm grass sod is not provided. Experience in Massachusetts demonstrates that the proportion of roadway traveled to that constructed is overestimated.

The forms of specifications for stone roads under the State Aid Law of New Jersey are given in the report of Mr. Henry J. Budd, Commissioner of Public Roads, Trenton, N. J., 1897, pages 143 *et seq.*, and those contemplating the construction of important roads will find much valuable information. The report of the Massachusetts Highway Commission, 1897, Appendix F, pp. 46 to 72, contains instructions to assistant division and resident engineers to guide them in their work.

Sub-drains.—In order to secure a dry foundation, the use of under drains is advised. They are not expensive and not difficult to lay. They may be of cement, tile, pipe or built of blocks of stone into rectangular conduits to absorb and carry off the excessive rains which otherwise would destroy the bed on which the road covering is laid. For sub-soil drains on a grade of six inches in a hundred, the pipe need not be larger than three inches for a length of 1,200 feet, four inches for a length of 2,000 feet, or five inches for a mile of continuous road.

Standard Sections



Longitudinal section line centre showing Macadam & rail
MASSACHUSETTS HIGHWAYS.

Their lower ends will discharge into some natural water course, and if properly laid, should be capable of taking the surplus surface flow, dry the earth above and prevent frost. The steeper the grade, the smaller, proportionately, may be made the pipe line. The tile pipe should not be overburned, warped or black, nor should they be soft and give a dead "punky" sound when struck with a hammer. The cost when laying pipe drains is from five to eight cents per foot for sizes up to and including twelve inches.

Breaking the Stone.—The size to which the stone of the covering is to be broken depends upon its quality and the amount of traffic to which the road will be subjected. The size of stone which makes the best wearing surface would seem to be the one of the largest possible dimensions, while possessing the power to bind and knit closely when rolled into place, and to present a smooth wearing surface. This is on the principle that large stones are stronger than small. Macadam's original rule was one inch in dimension, or three ounces in weight. There has been, however, a great diversity in selection by that which is found to be most serviceable, and to give a smooth roadway with the least expenditure of labor and money. The cost of crushing is, of course, lower as the size is larger, but the larger stones, unless thoroughly rolled, make a rough road. The smaller stone, on the other hand, would require quick renewals. The very common practice is to set the crusher jaws for a one and three-quarter-inch delivery. Larger than this size is certainly mischievous for any variety of stone except the softest. Undoubtedly the size is largely governed by the character of the surface material. Trap rock must be broken to small dimensions for road use to give equally good service with limestone which may be used to a limiting size of two inches.

The following comparative table will show the results of crushing three varieties of materials and the amount of labor involved in the same.

	Trap*.	Granite*.	Limestone.
Cubic yards broken,	3,155	1,785	4,324
Tons, of 2,240 pounds,	4,000	2,142	5,198
Time, hours,	412	198	270
Cubic yards per hour,	7.7	9.0	16
Cost per cubic yard of stone at crusher,	\$0.898	\$0.27	\$0.22
Sizes $2\frac{1}{2}$ inches, cubic yards,	1,618	994	2,490
Sizes 1 inch, cubic yards,	323	427	563
Sizes $\frac{1}{2}$ inch, cubic yards,	210	427	
Sizes tailings, cubic yards,	1,004	365	1,272

*From the Report of the Geological Survey of Maryland.

The rock crushers can be adjusted for any delivery within moderate limits. When they are set to furnish a given size, say one and three-quarter inches, they will produce considerable finer material. To preserve a uniformity of size in order to secure the most intimate contact with rolling, the big stones and the small stones must be eliminated by screenings. However careful the contractor or engineer may be to procure a uniform delivery of stone, it is the common experience that more material is rejected from the dump pile than is accepted.

In a recent bulletin of the State Secretary of Agriculture (No. 66) is found (page 37) an estimate of the cost of crushing and distributing. The same is estimated at 18 2-10 cents per cubic yard, on a basis of 70 cubic yards per day and 37 7-10 cents for distributing. The hauling is done with two teams and one helper. Trap costs nearly 57 cents per cubic yard for crushing.

As between machine and hand breaking of rock, it is difficult to determine the comparative cost, for local conditions vary to a high degree. There is no difference in the suitability of either variety of broken rock except that perhaps the product will be more uniform from the machine as it would necessarily be screened before delivery. One man can, with a long-handled two-pound hammer, break 2 1-12 cubic yards per day. Rock crushers may be had of various patterns to break from 40 perches a day up.

The thickness of the road metal need be only so much as will support the traffic and no thicker than is capable of being consolidated into an impervious roofing for the foundation. In Massachusetts the average thickness of macadam, which appears to be sufficient for the heaviest travel on light sub-soil, with a well drained sub-grade, is six inches. On Long Island and in Connecticut the thickness has been reduced from eight to five inches. It is a little heavier in the center than at the sides, and is usually put on in two layers, each having a thickness, when dumped from the cart, of about five inches at the center, and three and one-half at each side. On steep grades a four-inch, well-rolled covering has stood very satisfactorily. On flat grades a thicker layer would be preferred. The harder the rock used for surfacing and the more compactly it is rolled the thinner may be the layer, other things being equal. A thickness exceeding six inches is not required on any except the suburban streets.

The amount of material which would be required for road covering is given in the following table as also the cost per mile for the surfacing material on a basis of payment for it at prices ranging from twenty-five to forty-five cents per square yard laid at the different depths mentioned. This table copied from the report of Commission of H. J. Budd, of New Jersey, 1899, page 255, shows the number of tons of stone required to build one mile of road of the depths and

widths specified. This is given on the basis of 3,000 tons of loose stone or 3,500 tons of compressed stone for a road one mile long, 16 feet wide and 8 inches deep.

Width of Road.	Inches depth of rolled stone.	Tons of stone per mile.	Square yards surface in one mile.	Cost per Mile at Prices per Square Yard.				
				25 cents.	30 cents.	35 cents.	40 cents.	45 cents.
8 feet,	6	1,312.50	4,693	\$1,173 33	\$1,408 00	\$1,642.66	\$1,877 33	\$2,112 00
	8	1,760.00	4,693					
	10	2,187.50	4,693					
9 feet,	6	1,476.50	5,280	1,320 00	1,584 00	1,848 00	2,112 00	2,376 00
	8	1,968.75	5,280					
10 feet,	6	1,640.62	5,867	1,466 66	1,760 00	2,053 33	2,346 66	2,640 00
	8	2,187.50	5,867					
11 feet,	6	1,804.80	6,454	1,613 33	1,936 00	2,259 33	2,582 66	2,906 00
	8	2,406.12	6,454					
12 feet,	6	1,968.75	7,040	1,760 00	2,112 00	2,464 00	2,816 00	3,168 00
	8	2,625.00	7,040					
13 feet,	4	2,132.82	7,627	1,906 66	2,288 00	2,670 66	3,063 33	3,446 00
	6	2,843.75	7,627					
14 feet,	4	1,531.25	8,213	2,063 33	2,464 00	2,874 66	3,285 33	3,696 00
	6	2,236.87	8,213					

Settlements for material by the load have always given trouble. Estimates of quantities made per cart measurements are inaccurate because of the difference in their capacity. We, therefore, suggest that measurements be made in the pit, previously cross-sectioned with an agreed allowance for shrinkage, if it is not desired to have payment made by the ton. By the cart-load the settlements are vexatious. The report of Massachusetts Highway Commission, page 34, 1900, shows the difference in the capacity of eight double and three single teams used on one of the State roads; the volumes of the carts varied from 36 to 53.67 cubic feet for the double and 22.9 and 28.38 cubic feet for the single carts. The average capacity of the double carts was 1.648 cubic yards and of the single, 0.915 cubic yards. The actual loads hauled were 1.404 and 0.776 cubic yards, respectively, showing a shrinkage of 14.8 and 15.1 per cent. in the two sizes of carts.

The Use of Binding Material.—The crushed stone delivered upon the surface of the road-bed is of irregular shape and generally lacking the uniformity of size. The material can never be laid in close contact so as to exclude voids. These spaces must be filled, whether by the use of smaller particles or by rolling. In any event no amount

of rolling will bring these stones perfectly into contact. The volume of voids is a considerable portion of the whole mass. One cubic yard of solid rock weighing 2 1-14 tons will, when broken, occupy two cubic yards of macadam space. The voids must be filled or reduced to prevent infiltration of water. A solid roadway is obtained only by the use of fine screenings and repeated rolling. The smaller the amount of this filler that is placed on the road the better, but it should not be of material softer than the road ballast unless it has a high cementing quality. Hard pan is a material of the last resort. For the coarse, hard granite rocks, sand and granite screenings are advised. When the fragments do not bind well, they creep out of place and break off, thus roughening the traveling way. Hence, some engineers prefer the broken stone screenings. Out of twenty-eight interrogatories, Mr. Oastlar received only eight favoring gravel or sand filled, and seventeen engineers replying in favor of the stone being used.

Rolling.—The use of a filler will not alone make a solid covering, for the fragments must be keyed together. This may be accomplished by repeated travel over the surface of weighted wheels. These latter may be either broad cylinders propelled by a steam engine, heavy rollers pulled by horses, or the ordinary traffic. Unquestionably rolling is necessary, but the conditions which determine a choice of method are local. Generally speaking, however, while the road is in process of construction it is the opinion of the writer that the only circumstance which would justify the road masters in depending upon traffic to make his road is his inability to procure a roller. For, with the other methods which are available, it is possible to apply a heavy pressure over a considerable width of the road-bed, and thus to compact the mass much more uniformly than by the comparatively narrow tire of ordinary wagons. The latter would tend to harden only a narrow belt of the road under each wheel. As a matter of fact, however, the loose fragments will move and be dislodged instead of being forced into place, and in consequence will tend to encourage the formation of a rough rather than smooth surface. Until the fragments have been partially cemented, the travel should be restricted to broad-surfaced wheels if a high-grade road is desired. With soft rock, the arguments against a traffic made road have less force, but as the harder varieties of rock are employed the preference is revealed for the steam roller. The horse roller is a compromise between the two. It is not sufficient for trap or the harder varieties of road metal. The pressure which it can exert is much less than that which is obtained from the steam roller.

In contrasting the difference of the serviceability of the horse and steam roller, it is the experience of all with whom the writer has

spoken that the latter is preferable though the first cost of the steam roller is higher than for a horse roller—\$3,000 against \$400. The greater weight on the driving wheels of the latter as compared with the former makes the compression upon the road surface more effective. The pressure per square inch may be only 167 lbs. for the horse—and is from 400 to 700 lbs. for the steam roller. On a hard rock surface like trap, the horse roller is less effective, also, because the animals themselves often exert by their hoofs a pressure greater than that afforded by the roller surface in contact with the rock and they even dislodge loose material which is not easily pressed into place. The horse roller is not capable of doing work upon grades of more than 5 or 6 per cent., while a steam operated roller may be run effectively on a slope of twelve feet in a hundred. More trips must be made by a horse roller than by a steam roller to accomplish the same work, and as it cannot run backwards, like the steam roller, much time is lost in turning it around at the end of each run. The cost of operating a steam roller is between three and four dollars a day less than for the horse machine, and, taking into account that the former is several times as effective because of the greater compression, makes it far more economical than the horse for road surfaces of any kind.



Stone on a macadam road as it appears when spread ready for rolling.



Stone on a macadam road when partially rolled, showing how the roller packs it.



Stone on a macadam road, firmly wedged and packed together. Small stones, gravel, dirt, or sand if mixed with the stone or spread at the surface before rolling, prevent its being thoroughly wedged and packed.

The Volcanic Rocks require two or three times as much rolling to consolidate the surface as do the hardest varieties of limestone. They must get this amount of repeated rolling or else, if opened to the public too soon, the stone will loosen. Care in this regard must be exercised as it is absolutely essential that abundant rolling be given it. In some cases where this has been neglected the trap roads have received a bad name. The fault is not with the rock but with the manipulation. But once hardened and subjected to plenty of travel, the trap roads improve with age while the others deteriorate. The steam roller is recommended where the cost of construction and equipment is not too heavy for the county.

A sprinkling of the surface during the process of rolling aids in a speedy cementation of the fragments. Too much moisture, however, applied during construction would cause a wavy motion during rolling. According to the specifications of the Engineering Bureau

of Altoona, the appearance of the wavy motion before the roller determines the time of stoppage of the rolling.

Sprinkling.—The part played by water on crushed stone while undergoing rolling is several fold. The moisture prevents the loss of material which is worn down by the abrasive action; while spreading it permits a more thorough compact of the angular fragments, as it acts much like a lubricant, and in the later stages of the rolling preserves the dust formed during the construction. Its subsequent service during travel is well recognized. In regions where it is practiced, seventy cubic feet of water is the average consumption for 1,000 square yards of surface per day.

The State highways of Massachusetts are divided into eight classes, according to the character of the broken stone which is used as a covering. The character and thickness of the material is indicated below, being determined by the amount of traffic and the weight of the carriage loads.

"State highways are divided as follows, with reference to the broken stone (sizes given are in inches):

"a. All trap rock. Both courses to be $1\frac{1}{4}$ to $2\frac{1}{2}$.

"b. All trap rock. Both courses to be $1\frac{1}{4}$ to $2\frac{1}{2}$.

"c. Local stone other than trap. Bottom course to be $1\frac{1}{4}$ to $2\frac{1}{2}$; top course to be $\frac{1}{2}$ to $1\frac{1}{4}$.

"d. Local stone other than trap. Both courses to be $\frac{1}{2}$ to $2\frac{1}{2}$.

"e. Bottom course of local stone other than trap $\frac{1}{2}$ to $2\frac{1}{2}$; top course of trap rock $\frac{1}{2}$ to $1\frac{1}{4}$.

"f. Bottom course of local stone other than trap $\frac{1}{2}$ to $2\frac{1}{2}$; top course of trap rock $1\frac{1}{4}$ to $2\frac{1}{2}$.

"g. All trap rock. Bottom course to be $\frac{1}{2}$ to $1\frac{1}{2}$; top course to be $1\frac{1}{4}$ to $2\frac{1}{2}$.

"h. Local stone other than trap. Bottom course to be $\frac{1}{2}$ to $2\frac{1}{2}$; top course to be $1\frac{1}{4}$ to $2\frac{1}{2}$."

The Cost of Macadamizing Roads.—The cost of construction of a macadam surface, varying with the nature of the material employed, is between 40 and 80 cents per linear foot of road 16 feet wide, with a thickness greater than 4 inches and a distance of average haul more than a mile, the price will be greater than the above. Undoubtedly, good roads of local material can be laid eight or nine feet wide for a cost of \$2,000 per mile. In Massachusetts—including the cost of engineering, salaries, administration—for a 16-foot road-way, the expense reaches \$8,505.12 for macadam roads; \$6,807.25 for gravel roads. These estimates include material, surfacing and shaping. With culverts, bridges and embankment on side hill, the expense may reach \$9,000. Guard rails on both sides of the road, as illus-

trated opposite page 635, cost \$180 per mile. In New Jersey the average of the total mileage of roads built by State aid shows a 16-foot roadway to have cost \$4,800.00. The cost of brick pavements, completed with concrete foundations and gutters on either side, from \$1.10 to \$1.60 per square yard, as reported to me by twenty-six engineers in the State. This includes the excavation at 30 to 40 cents per cubic yard, concreting at 65 cents and sand at 5 cents. The cost of brick varies from \$10.00 to \$13.80 per thousand, according to locality.

The above figures seem high to the average citizen, but they represent the cost of a perfectly smooth roadway, on which the repairs and the interest are far below the amount formerly levied for road construction. They also represent roads built for exceptionally heavy and speedy travel. For the suburban and country districts the foundation need not be so heavy, nor will curbing and gutters be required and the cost of a 9-foot brick single track road should cost not more than \$3,000 per mile. Many of the macadamized roads of Maryland, where the conditions are so much like ours, have been built for less than \$2,000 per mile, and in the Cumberland Valley the turnpikes do not exceed \$3,000 per mile for construction. One road 12 feet wide and 6 inches thick was laid for \$1,000.00 in limestone; another, 14 feet wide and 9 inches thick cost \$1,800.00 per mile. Some of the United States object lesson roads have been built for \$2,000.00 per mile. One, in New Brunswick, had four inches of crushed stone, another layer of three inches limestone and a top dressing of trap.

The average cost of all classes of roads in New Jersey during 1899 was not far from 45 cents per linear foot of road 8 feet wide and 8 inches crushed stone cover. Those of a consolidated thickness of 4 inches and a width of 8 feet cost about \$1,173 per mile.

The initial cost of some broken stone roads in New York was \$1,000 per mile. Gravel roads were built for a little more than that. The Telford pavements cost about 75 cents per square yard for material alone.

Oil on Roads.—Dusty roads have been rendered dustless by the use of an oil sprinkler, which is repeated as often as occasion requires. A portable tank, with a sprinkling arrangement like that used for water is moved over the road during the dry season. A light covering of oil is formed which preserves admirably the material which would otherwise be blown or washed away. The method originated with F. W. Mattern, in California, and is very much in vogue. In the western States the idea has been successfully carried out. The first general treatment required fifty barrels per mile of road. Subsequent dressings were made at the rate of twenty barrels per mile. The first was given the road in the spring, the second during July.

The experience of many years has proven that the effect of these two doses lasts three years. The boulevard at Bryn Mawr has not been oiled for four years and was still in fine condition.

By the use of oil not only is the dust settled, but its cushion is preserved. The mass becomes hard and is impervious to water because of the repulsion between the two liquids. The effect of frost is diminished and the roadway will remain in good condition, winter and summer. The oiled dirt roads in Chester county were in fine condition this past dry summer.

THE NECESSITY FOR REPAIRS.

When this period of road construction is reached, the general idea is that that is all, but one may say here very emphatically, not yet. A new road, like a new watch, wants watching and adjusting to get it into a new permanent shape, and for the first year it wants to be looked after with some care.

The destruction of the surface and the raveling of the road by the action of the forces are inevitable evils with which the road master must combat. In order to preserve the road, he must rely upon the cementing qualities of the rock. A liberal application of sand during the wet season and sprinkling during the dry season of the year are good remedies. The employment by travelers of wide tires would help to preserve instead of destroy the road, and the avoidance of "Indian file" would prevent the formation of ruts. A road well constructed and thus cared for by the citizens will present a smooth surface over the entire roadway. The wear, however, is sure to follow travel and the removal of the debris cannot always be averted. A roadway must, therefore, require replenishment of material, according to the softness of its surface. The wear may be, or ought to be, uniform over the entire width and length. But some portions of the road are defective or subject to more severe scour and, therefore, wear out faster than the main body. Some of the road stones may be particularly soft, and, again, the foundation may have yielded in some places. Hence, pools or ruts mark the highway even if the material is so well bonded as not to ravel. Repairs will then be necessary, either by touching up stray spots or by recoating the surface according to the judgment and experience of the engineer.

The time when this repair should be made is always one to be determined by the patient endurance of the public or watchfulness of the road master. There seems at the present time to be no regular method, universally adopted in regard to repairs nor the time at which they are to be made nor the extent of such repairs. Engineers differ widely and no rule can be established. That it should be made as promptly as possible is certain, for all dilapidations increase in a

heavy ratio after they have once commenced. There seems to be, on the part of the taxpayers, a general apathy in the care of roads, except at such times as the citizen is attempting to make headway with a medium load over a badly kept road. In the past the necessity for repairs is conceded as evidenced by the regular levy of road taxes. Money is voted without protest. But it seems difficult now to educate a community to the need of repairs on a new road. There is sort of a recognized feeling that when it has once been built, that is the end of it. But far from it. Still, it is easier to ingraft into the minds of the commissioners the necessity for construction than the necessity for repairs. This is an undesirable state of affairs, for the repairs are neglected until the traveling way becomes too rough and uncomfortable. Then is created an undesirable impression upon the public mind against the stone road system.

Every argument for making good roads is one for keeping them so. It is an easy matter to make a good macadamized road. The art is based upon principles which every man of common sense can understand and apply, but the question of maintenance requires judgment and some experience in order that the expenditure of money may furnish a maximum of returns.

The animus of the American engineer is to accomplish the largest possible results with the minimum expenditure of time and labor. For this reason it is largely a matter of experience and judgment in determining whether a mere patching of the several weak spots in the surface is sufficient, or a complete re-surfacing of the length of road is necessary.

The average life of a well-made macadamized surface under ordinary country traffic is five years, during which time practically no repairs are required. There have been some well-constructed roads which have kept in good condition ten years without repairs. The question really is: "How far may a six-inch road covering be allowed to wear down without renewal without risking the security of the foundation?" This will largely depend upon the character and condition of the foundation bed. In France the road masters keep a continual supply of broken rock in neat piles on either side of the roadway, at distances of one-fourth mile apart. Some engineers argue that "A stitch in time saves nine," and maintain a supply of material similarly distributed at convenient places. As the scientific construction of improved roadways is a matter of this decade only, it is not possible yet for us to furnish any accurate data as to the amount of wear on prepared roads, nor have we been able to secure any census of traffic by which to determine wear and cost. The best road system in the world is probably that of France. The amount of rock repairs there used to replenish weak spots was 90 cubic yards per mile for the average traffic over 22,000 miles of road, corresponding to 170 loaded vehicles per year.

As an average taken from twenty-one American cities, it may be well to quote for comparison with that of a macadamized surface: The average life of trap blocks is twenty years; of wood pavements, eight years; of granite, sixteen years, and of brick, fifteen years, without repairs during that time.

Repairs of roads are perennial. The construction is incidental. Every four years on a limestone surface the addition of three inches of covering will be demanded; on trap rock, one inch of additional matter must be supplied every five years. The narrower the roads, the shorter is this period of repair.

The total points in the care of a road are as follows:

1. Keeping the surface of the road free from all deposits, dust or mud and other rubbish.
2. The filling of ruts and depressions due to defective construction of the earth bed or surface deficiencies.
3. Sprinkling in dry weather and rolling.
4. Keeping open the ditches, culverts and water courses.

The quality of material which is necessary to keep a certain stretch of 16-foot road in constant repair varies largely, and it may be stated that a mile of road of good material and under heavy travel would need twenty-five cubic yards per year. This may be disposed in piles containing a cubic yard each, spaced 200 feet apart. A pile six feet long, three feet wide and one and one-half feet high would contain about one yard. This material may be spread over the road surface in the places to be darned and rolled until a smooth, uniform surface is again obtained. Or, preferably, the old road might be picked and loosened before remetalling. In an article before the American Society of Civil Engineers, Mr. C. A. Oastler reported, Vol. XXVIII, page 39, that twenty-six out of twenty-eight prominent engineers from whom he received replies favored the use of picks with the steam roller before putting new ballast on old roads.

The cost of repairs varies with the season and the climate. Where the road is exposed to sweeping winds a raveling increases the expense beyond that which is necessary for the repairs of a road in a moist region. The estimates of cost on improved stone roads vary from \$10.00 to \$300.00 per mile, as reported by the Department of Agriculture. In the report of the Massachusetts Highway Commission for 1900, the annual amounts expended on roadways and maintenance per mile of finished road are tabulated for the several counties from \$29.52 to \$119.03, where heavy loads of iron ore pass frequently over the route. In many of the counties, however, the expenditure was larger than the above sum, but were excluded from those mentioned because they included a complete resurfacing for a considerable length of roadway.

In the matter of repairs a proper recoating of the entire surface in

a given locality has cost between twenty and twenty-two cents per linear foot for a road sixteen feet wide. For a width of nine feet, and assuming a renewal every five years, this would cost \$130.00 per mile on the average. In France the stone roads are kept in perpetually good condition at a yearly expense of only forty-eight cents per inhabitant. In answer to the question, "Is the cost of repairs to a stone road greater or less than the amount expended on the same before improvement?" the general reply was that it was less.

Should the taxes levied for repairs to roads be paid in cash or labor? Judging from the experience of States adopting an improved road system, the answer should be affirmative here. A money system would prove a long step toward road improvement. The Department of Agriculture for this State received, four years ago, replies from more than 3,000 road supervisors over the entire State to the above question, which shows a remarkable unanimity of opinion in favor of a cash mill tax for roads.

THE ADVANTAGES OF AN IMPROVED ROAD SYSTEM.

Though it is not our object here to point out the improvements of good roads but simply to call attention to the materials that should be used and those which should be avoided and the influence which their employment will have upon the method and system of construction; nevertheless, one cannot refrain from quoting some of the results which are gained by the employment of permanent roadways.

General Roy Stone, in a circular, No. 27, of the Office of Road Inquiry, shows that two-thirds of the vast expenditure of the \$946,414,665 for hauling crops to market in the United States is directly chargeable to the bad conditions of our roads. This is on a basis determined by him in reply to more than 10,000 circulars which were sent to the farmers in all parts of the United States. He ascertained that the average cost of hauling a ton one mile was twenty-five cents, which being twenty-two cents in the Prairie, Pacific and Mountain States, and rising as high as thirty-two cents in the eastern States. Compared with this we have the summarized average cost of hauling the farm products in England, and reported by our consuls there as a little less than ten cents per ton per mile; in Germany the average cost is six and one-half cents; in Switzerland, eight cents. Contrasting these figures with the average cost of haulage which was ascertained by the Maryland Geological Survey as reported for that State, whose topographic conditions are much like ours, it will be seen that we of this State must be hauling our loads at an expense of about eighteen cents per ton per mile more than improved roads would cost us. Again, Professor Eley has estimated that the loss per horse per year on account of bad roads amounts in the United

States to \$15.00, and figuring on that basis for the State of Pennsylvania, where we have about 618,000 horses, bad roads are costing us \$9,300,000 in horseflesh and harness.

The saving of eighteen cents per ton for every mile of haul and \$15.00 per horse every year, as may be accomplished by increasing the loads which can be carried to market and by the diminished exertion of overcoming grades and a tractional resistance of soft, rutty surfaces would amount to the annual sum in this State on this basis not far from \$14,000,000. In the entire State there are more than 100,000 miles of road, good, bad and indifferent. Most of them have been opened by the common laborers, without the application of any engineering skill. They have followed the pioneer routes located upon any known system. They have been maintained occasionally by abutting property holders during idle seasons of the year. It has cost over \$6,500,000* to keep them in such condition as they are. Most of the money was wasted because this sum was put upon the repair of roads poorly constructed and upon improvements which were duplicated the next year. These roads were impassable in portions of the year. It cost more to keep them than if they had been finely macadamized. Of all the great nations—America, the greatest—has actually the worst roads, though her progress in commerce, industries and conveniences of life have been most rapid in spite of them. So, too, Pennsylvania has been far behind her sister States, though she ranks first in the wealth of the natural resources and manufacturing industries. At present the farmers haul their products to market with difficulty and loss. It takes a good part of a life time in driving over the roads, vast sums in repairs to harness and involves loss of privileges of communication. This cannot be measured in dollars and cents, but, nevertheless, represent no insignificant sum. This burden falls upon the farmers yet, though the farms constitute less than one-fourth of the entire property of the State, that fraction bears the whole cost of building roads. This unjust levy falls also upon the heaviest loser in other respects. It would, therefore, seem equitable that the other industries should give aid to road construction and moneys be provided from some source of taxation, such as by State aid. Good roads would be expensive but are necessary for the development of a region, and none is so poor as will not be helped by them. Certainly, an improvement that would double the speed or double the load would bring the individual one-half nearer market, and, with care, enlarge his earning capacity and enhance the value of his land.

A choice between what is desirable and what is essential constitutes the problem with which the highway commissioner must deal.

* Report of Hon. J. A. Latta, 1899. This total excludes Philadelphia and Allegheny County's expenditure of \$4,821,544.05, on account of streets and roads.

This may be determined by the earning power of the road as a carriage way only. Certain it is that first-class roads may be made luxuries or extravagancies to be dreaded and likely to increase the burden of taxation without a measurable return. Others may be built without reducing the grade properly, or too short for comfortable grade, or over poor supporting foundation or covered with soft local material. But they will not save anything over the former waste in haulage, nor would they materially benefit the region. But any well-made and well-kept road should to some degree be a developer of the district, and how far it will give returns from the expenditure of its construction and maintenance is the main element of the engineer's problem. Advocates of good roads wish for the best. But the road supervisor, while seeking this end, must have regard for the annual taxes which will have to be levied for their construction. Hence, expensive as make shifts, he may be compelled to adopt them even against his will. That improved roads are approved by those living along their lines is unquestioned. That they will be appreciated in our State, there is no doubt. In New Jersey, the Commissioner has great difficulty in determining, out of the numerous applications from the citizens, the order in which the roads shall be built; in Massachusetts the clamor for improved roads has been so great that their construction has proceeded too rapidly for the highway commission to institute any system of allotment. The sentiment is growing in other States and undoubtedly must prevail here shortly. No argument is necessary to show that improved roads have increased the earning power of the districts which they traverse. It is sufficient to quote some figures from the United States Department of Agriculture, which are appended below:

Group of States.	Average haul, miles.	Average weight, lbs.	Average cost per 2,000 lbs. per mile.	Total average cost per ton for whole length of haul.
Eastern,	5.9	2,216	\$6 32	\$1 89
Northern,	6.9	.....	27	1 86
Middle,	8.8	.....	*31	*2 72
Cotton,	12.6	1,397	25	3 06
Prairie,	8.8	2,409	22	1 84
Pacific Coast and Mountain,	22.3	2,197	22	5 12
Whole United States,	12.3	2,008	25	3.02
Maryland,†	6.7	1,160	26	1 74

*Middle Southern States. †Maryland Geological Survey.

No single system of road management has prevailed throughout this State. There are no continuous boards of supervisors, but the

actual construction. The questions of topography, or relative merits and value of the available stone, direction and grade of the several connecting and intersecting portions are too broad for the local authorities to consider.

One matter of moment, which requires delicate as well as careful treatment by the highway commissions of the States now giving aid for roads, has been the selection of roadways to be rebuilt. In order to have a definite plan and ultimate purpose, the commission will be compelled gradually, if not formally, to determine routes and the order of their construction. The first set of roads were those which connected the main business centers. Then, those uniting the smaller and less populous towns with the cities. Next, come those districts remote from rail or water ways. Another group of localities outside of the State limits but adjacent to the Commonwealth, which would have natural outlets in its cities if it were not for the difficulties of the way, should be provided with good roads to the boundary line. Finally, there is presented to the Commissions the question of so grouping the State roads as to afford in the end continuous routes through the Commonwealth.

As soon as the policy has become settled, the tenure of office of the commissioners should provide for a continuous board to preserve the plan, and execute it to the best advantage. The States of Massachusetts and New Jersey are conducting such a system of administration that demonstrates the wisdom and value of supervision from a general center. The anxiety with which the less fortunate residents insist upon establishment of good roads along their fronts and the testimony given by the increased valuation of the lands along the improved ways are sufficient evidence of the estimate to be placed upon the proposed work for Pennsylvania. The saving in cost of haulage, the increased profits to the farmer, the greater comfort and speed for the traveler, the diminished cruelty to animals and the improved appearance of the roadways are objects to be attained worthy of the best efforts of a civilized race.

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THE REPRESSION OF TUBERCULOSIS OF CATTLE BY SANITATION.

AN ACCOUNT OF A SPECIAL INVESTIGATION TO DETERMINE THE INFLUENCE OF GOOD AND BAD STABLING CONDITIONS ON THE SPREAD OF TUBERCULOSIS.

BY LEONARD PEARSON, B. S., V. M. D., *State Veterinarian.*

SUMMARY.

The purpose of this investigation, which was made under the auspices of the State Live Stock Sanitary Board at the Veterinary Department of the University of Pennsylvania, was to measure the effect of good and bad stabling conditions on the progress of tuberculosis in two herds.

For the purpose of the investigation, two herds were established, of six cows each. Four cows in each herd were healthy and two cows in each herd were tubercular. One herd was kept in a roomy, light, clean, and well ventilated stable. The stalls and partitions between the mangers in this stable were so constructed that the cows were kept apart from each other.

The other stable was small, close, poorly ventilated, rather dark and not especially clean. The cows here were not separated by stall partitions, and they were all fed from the floor of the passageway in front of their stalls.

This experiment continued for 513 days or about 17 months, and at the close it was found that two of the originally healthy animals kept in the large, light stable, had contracted tuberculosis and the other two of the originally healthy cows continued sound. Of the four originally healthy cows in the small, dark stable, all had contracted tuberculosis. The progress of the disease in each infected animal in the dark stable was greater than in the infected animals in the light, airy stable.

It is concluded from this experiment that:

1. GOOD SANITARY CONDITIONS, CLEANLINESS AND THE COMPARATIVE ISOLATION AFFORDED BY SEPARATE MANAGERS AND BY STALL PARTITIONS, HAVE A DECIDED EF-

FECT IN RESTRICTING THE SPREAD OF TUBERCULOSIS IN AN INFECTED HERD.

2. A POORLY VENTILATED AND POORLY LIGHTED STABLE, AND ONE IN WHICH THE CATTLE COME INTO DIRECT CONTACT, AS IS THE CASE WHEN THERE ARE NO PARTITIONS BETWEEN THE STALLS AND MANGERS, IS FAVORABLE TO THE SPREAD OF TUBERCULOSIS IN AN INFECTED HERD.

3. HOWEVER GOOD THE CONSTRUCTION AND SANITARY CONDITIONS OF THE STABLE AND HOWEVER GOOD THE CARE OF THE ANIMALS MAY BE, THE SPREAD OF TUBERCULOSIS CANNOT BE ALTOGETHER PREVENTED IF TUBERCULAR CATTLE AND HEALTHY CATTLE ARE KEPT IN THE SAME STABLE.

The experiment under consideration was commenced on the 6th of June, 1898. I shall first describe the building in which the experiment was carried on, then the cattle used, and, finally, the care received by these animals and the results of their exposure.

The two stables that are described here are under the same roof, but in entirely different parts of the building. They are separated from each other by a solid brick wall. The doors of the stables are on opposite sides of the building so that the effect is the same as though they had been placed about 100 feet apart, this being the distance that it is necessary to go, out-of-doors, to pass from one stable to the other.

The larger stable is 33 feet 10 inches long and 23 feet and 10 inches wide. The height at the rear wall is 10 feet and 6 inches and at the front wall 11 feet and 9 inches. The capacity of this room is 8,970 cubic feet. The windows are placed close together on the west, south and east sides. There are no windows or doors in the north wall, as this is the solid brick partition dividing the stable from the rest of the building. The total glass area of the windows amounts to 200 square feet. There are two doors, one on the east and the other on the south side. The doors are 4x8 feet in size and each is divided into an upper and lower half, the upper half of each being kept open during warm weather, thus adding 32 square feet through which light is admitted.

This stable is ventilated by four sheet iron tubes, 18 inches in diameter, one of which is placed in each corner, and by an opening on the east side to permit the entrance of air. Each ventilating shaft starts one foot from the floor, passes out through the roof and

is surmounted by a metal ventilating cap. On the side of each shaft and close to the ceiling, there is an opening one foot wide and two feet long which may be closed by a slide. This is used in warm weather to remove warm air from the top of the stable, but in cold weather it is always closed. When this opening is closed, air enters the ventilators close to the floor.

The opening in the east door is a transverse slot 3 feet long and 10 inches high, 8 inches from the bottom of the door. This can be closed by a slide that falls from the top. On the inside of the door and in front of the slot there is a box that is closed on all sides, excepting the top. This box projects 4 inches from the face of the door. When the slide guarding this slot is pulled up, air enters from without and passes into the box, emerging from it at the top, passing in an upward direction. After many careful observations made for the purpose of determining the speed and direction of the air currents under different conditions, it was found that when all of the doors and windows were closed and the inlet for air on the east door was open and the air shafts were open only at the bottom, air passed out from the bottom of the stable through the ventilating shafts. When a door or window was open, air passed out at a higher level, through the door or window, and a downward current was established through the air shafts. By this system, the coldest and the foulest air in the stable is constantly removed from near the floor and the purer, warmer air in the upper part of the stable is conserved. The air of the stable is always very pure and scarcely any animal odor can be noticed and, although there is about 1,500 cubic feet of air space for each cow, the stable was warm and comfortable and did not freeze in the most severe weather, excepting once when the temperature out of doors was several degrees below zero.

The walls of this stable are made of brick and are coated with cement, thus making a very smooth surface. The ceiling is plastered on laths and painted. The floor is of cement. The six stalls are arranged in a row through the centre of the stable, the cows facing toward the east. The stalls are 4 feet wide and 5 feet long. The manure gutter is 16 inches wide and 6 inches deep. The mangers are cement basins, the walls of which rise 4 inches above the level of the floor, the bottom of each manger being level with the floor. These cement basins extend in a row in front of the stalls, each being as long as the stall is wide and 2 feet broad. The mangers are separated from each other by ridges of cement 4 inches high and by the wooden partitions described below.

The cows are fastened in swinging stanchions that are held in place by a few links of chain at the top and at the bottom. Between the cows' heads and separating the mangers, are wooden partitions made

of well matched boards, planed and painted. These are $4\frac{1}{2}$ feet high and $2\frac{1}{2}$ feet broad. In front of each manger there is a partition 2 feet high. Stall partitions separate the cows. These are $4\frac{1}{2}$ feet high at the front and $3\frac{1}{2}$ feet high at the rear and extend back 3 feet and 2 inches. All of the wood work of the partitions and mangers is secured in place by hooks and dowels and can be readily removed, so that it can be cleansed very thoroughly. The passageways in front of the mangers and behind the manure gutter are $7\frac{1}{2}$ feet wide. There is also a passageway 4 feet wide at each end of the row of stalls. No feed is stored in this room.

The other stable is 25 feet 10 inches long, 12 feet wide and 11 feet high. For the purpose of this experiment a temporary scaffold or ceiling was constructed of loose boards with spaces between, and upon this, straw was piled; this brought the ceiling down 3 feet or within 8 feet of the floor. With this arrangement the available air space was equivalent to about 3,000 cubic feet. There are two windows on the west side of this stable, but as these were boarded up during the experiment, they may be disregarded. The light that entered the stable, passed through 10 square feet of glass in a window beside the door at the north end and this window was closed excepting when men were working in the stable and during hot weather. That is, the window was closed about one-half of the period of the experiment. This stable was ventilated through two transoms, each $2\frac{1}{2}$ feet wide by 1 foot high. These transoms were partly closed during the coldest weather. In the summer the upper part of the door was left open. The area of this half-door space is 16 square feet. The walls of the stable are of rough bricks. The floor is of clay and cinders 10 inches deep and well compacted. The cows were confined in a row of stanchions extending from the south end of the stable to within 4 feet of the north end. That is, a space of 21 feet 10 inches was allowed for the six cows. There is a feeding passageway in front of the rows of stanchions 3 feet 6 inches wide, which is planked, and the cows are fed from this common floor, excepting the cow in stall No. 6.

There was but one partition in the stable to separate a cow from her neighbor and to isolate her feeding place. A solid partition $5\frac{1}{2}$ feet high of matched boards was constructed to shut off stall No. 6—the last one of the row. This was done to see whether such isolation would amount to anything in the way of protecting the cow from infection under the conditions that prevailed in the dark stable. This partition extended forward to the wall in front of the cows and a door in it had to be opened to feed the cow in stall No. 6.

The eight healthy cows used in this experiment were purchased from a drover who had just brought them from Ohio. The indi-

vidual animals are described at the end of this report. Each cow was tested by Dr. Michener on the 2d and 3d of May, 1898, and again by Dr. Shaw on the 18th and 19th of May, 1898. The dose of tuberculin used for the second test was twice the usual quantity. None of the cows reacted at either of these preliminary tests. During the progress of the experiment, they were tested on the 26th and 27th of September, 1898, and following this no test was made until the 17th and 18th of October, 1899.

The eight healthy cows were divided into two lots as nearly equal in all respects, as possible, and one lot of four cows was placed in the light stable while the other lot was placed in the dark one. The healthy cows were so distributed that they occupied stalls at the ends and at the middle of the row in each stable. This left two stalls in each stable, next to the end of each row, for tubercular cows.

This arrangement is indicated as follows (the letter T stands for tubercular cow and H for healthy cow):

Order of cows,	H	T	H	H	T	H
Number of stalls,	1	2	3	4	5	6

It will be observed that each healthy cow stood next to a cow with tuberculosis.

The tubercular cattle used in this experiment were animals that had been condemned and were kept for a time for this purpose before they died or were destroyed. Eight tubercular cows were used at different times during this experiment, but not more than four, two in each stable, were used at any one time. The stage of infection in these animals varied in intensity from mild incipient lesions to advanced generalized disease.

One tubercular cow, No. 5986, was used throughout the entire experiment. This cow was thought, when she was first obtained for this work, to be afflicted with tuberculosis in a very advanced stage. Her weight on June 6, 1898, was 775 pounds. She was very thin and coughed a great deal. During the progress of the experiment she gained 130 pounds, and weighed, just before she was killed on December 9, 1899, 909 pounds. Sputum was collected from this cow and examined by Dr. Ravenel, who found tubercle bacilli in vast numbers in every sample examined. About one year before the death of the cow, that is, December, 1898, the udder became noduled. The hard nodular areas within the udder increased in size until, finally, one-half of the udder was hard and swollen. This cow yielded milk of terrific virulence containing vast numbers of tubercle bacilli. Upon post mortem examination, it was found that two-thirds of the lung tissue was the seat of lesions of tuberculosis. Cheesy

areas were also present in the post pharyngeal lymphatic glands which were much enlarged. Some of the mesenteric lymphatic glands were from 5 to 8 inches in length and 3 inches thick, being full of cheesy debris. The udder and the supra-mammary lymphatic glands were extensively tubercular.

It was rather surprising that this cow should have gained 130 pounds during the 523 days that she was under observation; but it is even more surprising to know that all the other tubercular cattle in the experiment gained in weight while the experiment was under way. For example, cow No. 7921, Jersey, 3 years old, was brought into the experiment as one of the infected cows on June 23, 1898. At that time she was thin, the coat was harsh and dry, the skin tight and she coughed considerably. Her weight was 705 pounds. She was kept in the experiment 139 days and gained 140 pounds, practically 1 pound a day. This cow was killed on the 1st of December, 1898, and it was then found that both lungs contained a great many tubercular abscesses, the walls of which were thick and incrustated with lime salts. The surface of each lung was pretty thickly covered with tubercular growths, many of which seemed to be of quite recent formation. The anterior and posterior mediastinal glands contained old tubercular abscesses with thick walls. Many tubercular growths were also found on the peritoneum, and these lesions seemed to be of recent development.

Cow No. 7605, was obtained at the beginning of the experiment. She was a red and white cow, 9 years old. She weighed at the beginning 731 pounds, and on November 3, 863 pounds; that is, she gained 132 pounds in 122 days. This cow was not extensively tubercular, lesions being confined to small areas in the lungs.

The other tubercular cattle used in the experiment gained somewhat in weight. All of these cows when brought into the experiment, were regarded as advanced cases. They had reacted to the tuberculin test, they showed physical signs of tuberculosis, and they were all out of condition and losing weight. After they were brought into the experiment, if they were milking, they were dried off as rapidly as possible and were well fed. This appears to be the reason for their gain in weight during all but the very last stages of the disease.

In order that the exposure of the cattle in the light and in the dark stable might be as nearly equal as possible in respect to the number of tubercular bacilli discharged into the stable by tubercular cattle, and to prevent any irregularity that might arise from the presence of more advanced cases in one stable than in the other, the tubercular cows were changed every ten days from one stable to the other. That is, every ten days the two tubercular cows

in the light stable were transferred to the dark stable, and the two tubercular cows in the dark stable were transferred to the light one. As the dark stable was dusty and the cattle in it were not groomed, the tubercular cows from that stable were sponged off with a solution of creolin before they were placed in the light stable.

The food of the two lots of cattle was the same. They were given rations composed of corn, bran, oats, linseed cake and mixed hay. The nutritive ratio was approximately 1 to 6.5. Each cow was allowed about 8 pounds of grain a day and the cattle in the two stables were fed precisely alike.

The cows were confined all of the time, excepting when they were led out of the stable once a week to be weighed. The confinement did not appear to harm any of the cattle by causing injury to their legs or feet, excepting in the case of cow No. 6520 in the dark stable which was troubled some with hoof ail and required treatment, now and then, to keep this disease in check.

Both lots of cattle were cared for by the same men, but special overshoes and overgarments were worn in the dark stable and these were kept outside of the door of that stable. In attending to the stable work, the men first fed and milked the cows in the light stable and cleaned out the manure and afterwards attended to the cattle in the dark stable.

The light stable was kept scrupulously clean at all times. Not only was the manure cleaned out three times a day, but the stall partitions and the mangers were washed off with a disinfectant every day. The whole stable, including the floor, walls, ceiling, windows, mangers, and all of the wood work were scrubbed with water and soap once a week. The walls were kept white with magnite ("water paint"). The ceiling, window frames, doors, partitions between the stalls and mangers and the posts were kept freshly painted; a new coat of paint being applied whenever there was any cracking or peeling. The floor of the light stable, before it was swept, was sprinkled with saw dust wet with an antiseptic solution. In sweeping, a floor brush was used in place of the ordinary broom for the reason that it could be used without making so much dust.

For bedding, planer shavings were used. These are very clean and less dusty than any other kind of bedding. It was found that some of the shavings were knocked into the mangers by the cows and it was necessary to clean the mangers before feeding. For this purpose, brushes of straw were used, one for each cow. These brushes were kept in front of the stalls to which they belonged and each brush was used for cleaning the manger of but one certain cow.

The cows were watered from buckets. The buckets were marked with numbers corresponding to the numbers of the stalls. In this

way each bucket was reserved for the use of an individual cow and was not used for any other. The cows in this stable were groomed carefully. Two sets of curry combs, brushes, etc., were employed; one set for the two tubercular cows and the other set for the four originally healthy cows. These sets of utensils were kept in separate boxes outside of the stable.

In the dark stable, the cows were cared for in a less careful way, excepting in the matter of feeding and watering. The food was of the same quantity and quality as that used in the light stable and for watering, separate buckets were used, as in the other stable. The manure was removed twice daily. The cows were bedded with straw, and they were groomed only at long intervals. The scaffolding, in the top of the stable loaded with straw, made an uneven surface upon which spiders spun their webs. In the course of time long festoons of dusty cobwebs collected and were permitted to remain.

It will be seen that in the light stable everything was done to avoid a dusty atmosphere and to make it impossible for tubercle bacilli to accumulate. In the dark stable a dusty atmosphere was favored and the accumulation of organisms was permitted.

During the summer, the stables were shielded by awnings, which were lowered only while the sun was shining upon the part of the stable that could be protected by them. The awnings were not used excepting on hot days. On the whole, the stables were very comfortable both in summer and winter.

The cows in the dark stable gained more in weight than those in the light stable. The total gain for the four originally healthy cows in the light stable, during the entire period of the experiment, was 566 pounds, and of the four originally healthy cows in the dark stable it was 612 pounds. The cows in the light stable had a decidedly vigorous appearance, while those in the dark stable were, comparatively, sluggish and dull.

As to the results of the exposure carried out under these conditions, it will be observed that when the first tuberculin test was made, 82 days after the beginning of the experiment, one of the four originally healthy cows in the light stable and two of the originally healthy cows in the dark stable reacted, so that up to that point 25 per cent. of the exposed animals in the light stable had contracted tuberculosis and 50 per cent. of the animals in the dark stable had contracted tuberculosis. When the tuberculin test was applied October 17 and 18, 1899, fifteen months after the beginning of the experiment, it was found that two of the four originally healthy cows in the light stable reacted and all of the originally healthy cows in the dark stable reacted, so that at this time 50 per cent. of the exposed animals in the light stable were infected and 100 per cent. of the exposed animals in the dark stable were infected.

By reference to the description of the individuals used in the experiment, it will be observed that the lesions found in the cows infected in the dark stable were more wide spread and more extensive than in the cows infected in the light stable.

There were several ways by which tubercle bacilli may have passed from the tubercular to the healthy cows in the dark stable. There were no partitions between these cows' heads nor between their stalls. They could breathe upon such other, cough upon and toward each other and lick up food from surfaces that had been fed from and coughed upon by tubercular cows. From the distribution of the lesions in the cows that became affected, it seems probable that some of them had acquired infection by swallowing tubercle bacilli, and others by inhaling them. This, however, is a matter upon which it is difficult to form an opinion, because the age of a tubercular lesion can not be determined accurately. In this stable, tubercle bacilli floated in the air as dust. The rough surfaces, the straw ceiling, the cobwebs, all served as resting places for dust, whence it could be dislodged into the atmosphere by a gust of air or by the movements of the animals and thus once more come within the reach of the cattle. Fragments of food, etc., were allowed to collect on the feeding floor and on the wall in front of it. As these masses, together with the material expectorated by tubercular cows in coughing, were dried and pulverized, they entered the air as dust and could then be inhaled or swallowed. That tubercle bacilli were carried in the air in the dark stable was shown by the infection of the cow in stall No. 6, which was cut off from direct contact with the tubercular cow in the next stall. The same thing is shown more clearly by the infection of a guinea pig kept for four months in a cage suspended from the ceiling in the middle of the stable. The guinea pig died of tuberculosis. The lesions were distributed throughout both body cavities.

In the light stable, the cows were separated by partitions between their stalls and their mangers. They could not come into direct contact with each other. The food of one cow could not be contaminated by another cow by coughing upon it. No accumulation of dirt of any sort was permitted. It seems, therefore, that in this case infection must have been carried by tubercle bacilli suspended in drops of moisture sprayed from the respiratory passage by violent expiration, as in coughing. Guinea pigs kept in a cage suspended from the ceiling of this stable remained sound.

To test the virulence of the sputum of infected cows, Dr. Ravenel made some examinations of samples collected in nose-bags suspended from the muzzles of the tubercular cattle. He reports: "Of

thirty-four examinations carried out on five different animals, tubercle bacilli were detected by microscopic examination twenty times. The number of bacilli found varied greatly, but one of the five animals constantly coughed up tenacious mucous in which the numbers approached those seen in human sputum in very advanced cases." By this method he was able to detect tubercle bacilli in the expectorations or saliva of every tubercular cow on which it was tried.

Since this stable was always so free from dust and as nearly perfectly clean as it could possibly be kept, no other explanation of the transference of infectious material has occurred to me. If the tubercle bacilli were distributed in this way, it would appear that all of the cows in the stable were exposed to them and approximately to the same extent because, necessarily, as many tubercle bacilli were discharged in the vicinity of one cow as in the vicinity of another. But when they are projected into the atmosphere of a large, well ventilated stable (that is, one in which there is frequent renewal of air), the number of tubercle bacilli that can come within reach of an individual cow must be comparatively small. It is, probable therefore, that of the four originally healthy cows in the light stable, each was exposed to approximately the same number of tubercle bacilli, but in two of these cows this number of germs was not sufficient to produce infection. Two cows were able to resist and to destroy the limited numbers of tubercle bacilli that entered their bodies. It may be that they would have become infected if the experiment had continued longer. Whether they would have yielded to the attacks of the same number of organisms had they been confined in a badly ventilated, dark stable, is an interesting question. This question cannot be answered by the result of this experiment, because the cows that were confined in the dark, badly ventilated stable were also exposed to more tubercle bacilli, since they were in more direct contact with the diseased cattle that were excreting them.

There can be no doubt, however, that the cows in the light stable were, at the close of the experiment, possessed of more vigor and strength than those in the dark one. This was shown clearly by their bright appearance and the activity and strength of their movements when they were led out of the stable to be weighed.

It is to be observed that the cows in the dark stable put on more weight with the same feed than did those in the light one. The gain made by the four originally healthy cows in the light stable during the experiment was 566 pounds, and the gain made by the four originally healthy cows in the dark stable was 612 pounds. It is common to regard an animal increasing in weight as an animal that is healthy, but that this is not always the case is shown clearly by this experiment, wherein the animals that were

most extensively diseased increased in weight most rapidly. This fact comes out very strikingly when we compute the gains made during the different periods of the experiment. During the last period, that is, from June, 1899, to November, 1899, we find that the four originally healthy cows in the light stable gained 212 pounds and the four originally healthy ones in the dark stable gained 321 pounds. That is, the total gains made by four cows all of which were markedly tubercular was 51 per cent. more than the gains made by four cows fed in the same way and only two of which were tubercular. During the last four months of the experiment, the two cows that had contracted tuberculosis in the light stable gained 127 pounds and the two cows remaining healthy in the same stable, receiving the same food, gained 85 pounds.

It seems probable that an animal afflicted with tuberculosis is, in some stages of the disease, more inclined than a healthy animal to lay on fat. This tendency is sometimes marked until a rather advanced stage of the disease.

The question may be asked, could not the disease become latent in the two cows infected in the light stable, in view of their good hygienic surroundings? In answer to this question, it may be said that these conditions were not sufficient to prevent these animals from becoming infected, nor to prevent the disease from reaching a certain and considerable development. There is, therefore, no reason to suppose that the same conditions continued could check the disease after it was thus well established.

As to what would have occurred if the animals had been given exercise out of doors, we cannot foresee. Of course, it is well known that fresh air is one of the best remedies for consumption. However, the cows in the light stable had plenty of fresh air. They had practically as much oxygen as they could have gotten out of doors and were protected from the weather. The only thing that they were deprived of was exercise. Exercise was not allowed because it was the purpose of the experiment to compare stable conditions, and it was desired to know just what results would follow the stabling together of tubercular and healthy cattle under certain conditions, apart from other influences.

Cow No. 7911. Brindle and white cow, dehorned, age 8 years. Brought from Ohio to Montgomery county, Pa., and purchased there May 5, 1898. She had a heifer calf on June 9, 1898. Her weights were as follows:*

June, 1898,	865 pounds.
January, 1899,	833 pounds.

* All the cows in this experiment were weighed every week, on Monday. The weights here given are the averages of the weights for the months specified.

June, 1899,	966 pounds.
November, 1899,	1,020 pounds.

This cow did not react upon either of the preliminary tests. The other tests were as follows:

September 26, 1898.—8 A. M., 101.6; 1 P. M., 101.2; 10 P. M., 101.6.

0.8 c. c. of tuberculin 9-26 at 10 P. M.

September 27, 1898.—4 A. M., 103; 6 A. M., 104; 8 A. M., 104.1; 10 A. M., 104.4; 12 N., 106.8; 2 P. M., 105.8; 4 P. M., 105.8.

October 17, 1899.—12 N., 101.4; 6 P. M., 102; 9 P. M., 101.4.

0.8 c. c. of tuberculin 10-17 at 10 P. M.

October 18, 1899.—5 A. M., 101.8; 7 A. M., 102.8; 9 A. M., 104; 11 A. M., 105.6; 1 P. M., 105.6; 3 P. M., 106; 5 P. M., 105.4.

This cow occupied stall No. 1 (the north stall) in the light stable. She remained in very good condition throughout the experiment, and did not cough or show symptoms of any disease. She was killed December 9, 1899. The condition of nutrition was very good. There was much subcutaneous and abdominal fat. In the left lung, in the upper part of the middle lobe, there was a cheesy tubercular area one and one-half inches in diameter, and a short distance below it another similar area one inch in diameter. The mediastinal glands, both anterior and posterior, were enlarged to three times the normal size and contained cheesy foci from one and one-fourth to one and one-half inches in diameter. All other organs were normal.

Cow No. 6533. Red and white cow, dehorned, age 9 years. This cow was brought from Ohio to Montgomery county, Pa., and purchased there May 5, 1898. She had a bull calf June 9, 1898. Her weights were as follows:

June, 1898,	1,015 pounds.
January, 1899,	1,092 pounds.
June, 1899,	1,196 pounds.
November, 1899,	1,225 pounds.

This cow did not react upon either of the preliminary tests. The other tests resulted as follows:

September 26, 1898.—8 A. M., 101.2; 1 P. M., 101.2; 10 P. M., 101.5.

0.8 c. c. of tuberculin 9-26 at 10 P. M.

September 27, 1898.—4 A. M., 101.4; 6 A. M., 101.2; 8 A. M., 101; 10 A. M., 101.3; 12 N., 102; 2 P. M., 101.8; 4 P. M., 102.

October 17, 1899.—12 N., 101.5; 6 P. M., 102.1; 9 P. M., 102.2.

0.8 c. c. of tuberculin 10-17 at 10 P. M.

October 18, 1899.—5 P. M., 101.5; 7 P. M., 101; 9 P. M., 101.5; 11 P. M., 101.4; 1 P. M., 101.2; 3 P. M., 102.4; 5 P. M., 102.8.

This cow occupied stall No. 3 in the light stable. She remained in very good condition throughout the experiment and did not cough nor show symptoms of disease. She was killed February 10, 1900, and no lesions of tuberculosis were found.

Cow No. 7912. Fawn colored cow, dehorned, age 3 years. Brought from Ohio to Montgomery county, Pa., and purchased there May 5, 1898. She had a heifer calf on June 21, 1898. Her weights were as follows:

June, 1898,	782 pounds.
January 1899,	774 pounds.
June, 1899,	791 pounds.
November, 1899,	864 pounds.

This cow did not react upon either of the preliminary tests. The other tests resulted as follows:

September 26, 1898.—8 A. M., 101.5; 1 P. M., 102; 10 P. M., 102.

0.8 c. c. of tuberculin 9-26 at 10 P. M.

September 27, 1898.—4 A. M., 102; 6 A. M., 102; 8 A. M., 101.5; 10 A. M., 102.2; 12 N., 102; 2 P. M., 101.8; 4 P. M., 102.

October 17, 1899.—12 N., 101.2; 6 P. M., 102.6; 9 P. M., 101.7.

0.8 c. c. of tuberculin 10-17 at 10 P. M.

October 18, 1899.—5 A. M., 104.4; 7 A. M., 105.2; 9 A. M., 106.4; 11 A. M., 106.4; 1 P. M., 106.2; 3 P. M., 106.2; 5 P. M., 105.1.

This cow occupied stall No. 4 in the light stable. She was in good condition throughout the experiment, excepting for four months from September 26, 1898. On that day she fell on the cement floor while she was being taken out to be weighed. The left hip joint was bruised, making the cow lame and uncomfortable for about three months. The animal was not restored to her original condition for another month.

This cow was killed December 4, 1899. The condition of nutrition was good. There was considerable fat around the kidneys and intestines. On the right costal pleura there were cauliflower-like growths along the lower portion. The largest of these was three inches in diameter and one-half inch thick. The surface covered by them was about 12 inches long and from 6 to 12 inches broad. At the lower part of the right lung there was a tubercular mass 3 inches in diameter of cauliflower-like appearance. Upon section it was found that this growth contained cheesy pus. There was also a small mass of the same character one inch in diameter at the anterior extremity of the anterior lobe of the right lung. The pleurae of the left side and of the left lung were normal. The mediastinal and bronchial glands were cheesy. All other organs were normal.

Cow No. 7648. Red and white grade Guernsey cow, age 9 years. This cow was brought from Ohio to Montgomery county, Pa., and purchased there June 3, 1898. She had a heifer calf on June 3, 1898. Her weights were as follows:

June, 1898,	716 pounds.
January, 1899,	797 pounds.
June, 1899,	779 pounds.
November, 1899,	835 pounds.

This cow did not react to either of the preliminary tests. The other tests resulted as follows:

September 26, 1898.—8 A. M., 101.8; 1 P. M., 101.2; 10 P. M., 101.6.
0.8 c. c. of tuberculin 9-26 at 10 P. M.

September 27, 1898.—4 A. M., 101.8; 6 A. M., 101.8; 8 A. M., 101.8;
10 A. M., 101.6; 12 N., 101.7; 2 P. M., 101.6; 4 P. M., 101.5.

October 17, 1899.—12 N. 101.2; 6 P. M., 102.3; 9 P. M., 101.4.
0.8 c. c. of tuberculin 10-17 at 10 P. M.

October 18, 1899.—5 A. M., 101.8; 7 A. M., 101.1; 9 A. M., 101.2;
11 A. M., 101.8; 1 P. M., 102.3; 3 P. M., 102.2; 5 P. M., 102.2.

This cow occupied stall No. 6 in the light stable. She did not cough nor show any indication of disease throughout the experiment. She was killed February 10, 1900, and no lesions of tuberculosis were found.

Cow No. 7920. Black cow, age 8 years. This cow was brought from Ohio to Montgomery county, Pa., and purchased there May 15, 1898. She had a heifer calf April 20, 1898. Her weights were as follows:

June, 1898,	897 pounds.
January, 1899,	976 pounds.
June, 1899,	937 pounds.
November, 1899,	957 pounds.

This cow did not react to either of the preliminary tests. The other tests resulted as follows:

September 26, 1898.—8 A. M., 100; 1 P. M., 101; 10 P. M., 101.2.
0.8 c. c. of tuberculin 9-26 at 10 P. M.

September 27, 1898.—4 A. M., 101.7; 6 A. M., 100.6; 8 A. M., 101;
10 A. M., 102.7; 12 N., 105; 2 P. M., 105; 4 P. M., 104.3.

October 17, 1899.—12 N. 101.5; 6 P. M., 102.7; 9 P. M., 103.2.
0.8 c. c. of tuberculin 10-17 at 10 P. M.

October 18, 1899.—5 A. M., 102.6; 7 A. M., 102.7; 9 A. M., 103.2;
11 A. M., 104.3; 1 P. M., 103.7; 3 P. M., 102.6; 5 P. M., 102.

This cow occupied stall No. 1 in the dark stable. She commenced to go back in condition in the early part of the summer of 1899. This loss of condition was not shown so much by loss of weight as it was

by the rough, harsh coat, tight skin and by a certain loss of vigor. In the later part of the summer, beginning about August, the cow coughed badly and this symptom became more prominent until she was killed on November 10, 1899. The following is a report of the post-mortem examination:

The costal pleurae were studded with many small nodules about one-fourth of an inch in diameter. Some of these contained cheesy pus, others were of bright red color. The left lung had a few nodules of similar character on its surface but none in its substance. The right lung had, along the lower border, a number of mushroom-shaped growths one-half to one inch in diameter. These were found on the anterior, middle and posterior lobes and extended upward for from two and one-half to three inches from the lower border. A cheesy mass one-half inch in diameter was found in the substance of the middle lobe of the right lung, and close to the lower border a similar lesion was found, also one in the lower part of the anterior lobe. The surface of the posterior lobe was almost completely covered by mushroom-like growths. The supra-sternal gland had a number of calcified nodules. The mediastinal glands were considerably enlarged and contained many nodules, some of which were cheesy and others calcified. The anterior surface of the diaphragm was covered with tubercular growths from one to two inches thick and containing many large and small cheesy foci. The posterior surface of the diaphragm was thickly studded with gray tubercular nodules up to the size of a split pea. The omentum and the visceral layers of the peritoneum were thickly studded with nodules one-sixteenth of an inch in diameter and with shreds of fibrin one-half to one inch long. The anterior surface of the liver showed a great many mushroom-like growths that were attached only to the capsule and easily removable. These were from one-thirty-second to three-fourths of an inch in diameter. Upon section the liver was normal. A few of the mesenteric glands were large and cheesy. The lymphatic glands of the udder were enlarged and congested. The left post pharyngeal lymphatic gland was enlarged and almost double its normal size and contained two yellow cheesy foci one-half inch in diameter, each of which was surrounded by strong, fibrous walls.

Cow No. 6520. Roan cow, dehorned, age 7 years. This cow was brought from Ohio to Montgomery county, Pa., and purchased there May 5, 1898. She had a calf on April 20, 1898. Her weights were as follows:

June, 1898,	951 pounds.
January, 1899,	1,004 pounds.
June, 1899,	995 pounds.
November, 1899,	1,104 pounds.

This cow did not respond to either of the preliminary tests. The other tests resulted as follows:

September 26, 1898.—8 A. M., 101.6; 1 P. M., 102; 10 P. M., 102.4.
0.8 c. c. of tuberculin 9-26 at 10 P. M.

September 27, 1898.—4 A. M., 102.3; 6 A. M., 101.6; 8 A. M., 100.6; 10 A. M., 100.3; 12 N., 101.3; 2 P. M., 101.5; 4 P. M., 101.6.

October 17, 1899.—12 N. 101.5; 6 P. M., 102.2; 9 P. M., 101.9.
0.8 c. c. of tuberculin 10-17 at 10 P. M.

October 18, 1899.—5 A. M., 102.5; 7 A. M., 103; 9 A. M., 104; 11 A. M., 105.3; 1 P. M., 105.2; 3 P. M., 105.2; 5 P. M., 103.8.

This cow occupied stall No. 3 in the dark stable. She remained in good condition throughout the experiment and was killed November 29, 1899. The animal was well nourished and had a great deal of fat around the kidneys and intestines. On the upper part of the left lung there were a number of cauliflower-like growths three-fourths of an inch in diameter. A number of similar and smaller growths occurred on the outer surface of the posterior lobes and several on the median surface. One of the latter was three inches in diameter. All of these contained cheesy pus. In the substance of each lung there were a number of tubercular nodules from one to two inches in diameter. The left bronchial gland was the size of an orange and cheesy. Two mesenteric lymphatic glands were enlarged and cheesy.

Cow No. 7915. Roan cow, age 7 years. This cow was brought from Ohio to Montgomery county, Pa., and purchased there May 15, 1898. She had a calf June 20, 1898. Her weights were as follows:

June, 1898,	900 pounds.
January, 1899,	924 pounds.
June, 1899,	1,019 pounds.
November, 1899,	1,115 pounds.

This cow did not respond to either of the preliminary tests. The other tests resulted as follows:

September 26, 1898.—8 A. M., 102; 1 P. M., 102; 10 P. M., 101.6.
0.8 c. c. of tuberculin 9-26 at 10 P. M.

September 27, 1898.—4 A. M., 104.7; 6 A. M., 105; 8 A. M., 104.8; 10 A. M., 105; 12 N., 105; 2 P. M., 104.2; 4 P. M., 103.

October 17, 1899.—12 N., 101.2; 6 P. M., 101.8; 9 P. M., 101.6.
0.8 c. c. of tuberculin 10-17 at 10 P. M.

October 18, 1899.—5 A. M., 104.4; 7 A. M., 105.2; 9 A. M., 106.5; 11 A. M., 106.2; 1 P. M., 105.4; 3 P. M., 105; 5 P. M., 104.9.

This cow occupied stall No. 4 in the dark stable. She remained in fair condition throughout the experiment but coughed some for the last three months; still, not more than many non-tubercular cows cough, and scarcely enough to attract attention. She was killed

October 29, 1899. General condition was good. There was much subcutaneous and abdominal fat. In the middle lobe of the left lung there were six tubercular areas from one-half to two inches in diameter, broken down and cheesy. There were many smaller tubercular nodules the size of a pea. The right lung had many small cheesy foci from one-fourth to one inch in diameter. The bronchial glands were enlarged and cheesy. One post pharyngeal gland was tubercular. The udder appeared to be normal, as were its lymphatic glands. This cow gave infectious milk during a part of the experiment.

Cow No. 7914. White cow, age 4 years. This cow was brought from Ohio to Montgomery county, Pa., and purchased there May 5, 1898. She had a bull calf on May 21, 1898. The weights of this cow were as follows:

June, 1898,	752 pounds.
January, 1899,	825 pounds.
June, 1899,	850 pounds.
November, 1899,	946 pounds.

This cow did not respond to either of the preliminary tests. The other tests resulted as follows:

September 26, 1898.—8 A. M., 101; 1 P. M., 102; 10 P. M., 101.5.

0.8 c. c. of tuberculin 9-26 at 10 P. M.

September 27, 1898.—4 A. M., 101.9; 6 A. M., 101.4; 8 A. M., 101; 10 A. M., 101.4; 12 N., 102.2; 2 P. M., 102.5; 4 P. M., 101.9.

October 17, 1899.—12 N. 101.7; 6 P. M., 101.1; 9 P. M., 102.2.

0.8 c. c. of tuberculin 10-17 at 10 P. M.

October 18, 1899.—5 A. M., 102.9; 7 A. M., 102.8; 9 A. M., 104.3; 11 A. M., 105.6; 1 P. M., 104.9; 3 P. M., 104; 5 P. M., 103.5.

This cow occupied stall No. 6 in the dark stable. She remained in very good condition throughout the entire experiment. She was killed December 1, 1899. At that time the condition of nutrition was good. There was considerable subcutaneous fat and also a good deal of abdominal fat. In the right lung there were six small areas close to the surface containing yellow cheesy pus. The left lung contained more lesions of a similar character, the largest being about two and one-half inches in diameter. The left bronchial and mediastinal glands were enlarged and cheesy. On the posterior face of the diaphragm there was a hard fibrous growth three inches in diameter and two inches thick. In the centre of this was a cheesy area about one-half inch in diameter, just beneath the capsule.



COMMONWEALTH OF PENNSYLVANIA.

DEPARTMENT OF AGRICULTURE.



TABULATED ANALYSES

OF

COMMERCIAL FERTILIZERS

FROM

SAMPLES SELECTED IN ACCORDANCE WITH ACT OF JUNE 28, 1879,

BY THE

Pennsylvania Department of Agriculture.

FROM JANUARY 1st, 1900, TO DECEMBER 31st, 1900.



AN ACT

To regulate the manufacture and sale of commercial fertilizers.

Section 1. Be it enacted, &c., That every package of commercial fertilizer sold, offered or exposed for sale for manurial purposes within this Commonwealth, shall have plainly stamped thereon the name of the manufacturer, the place of manufacture, the net weight of its contents, and an analysis stating the percentage therein contained of nitrogen, or its equivalent in ammonia, in an available form, of potash soluble in water, of soluble and reverted phosphoric acid, and of insoluble phosphoric acid: Provided, That any commercial fertilizer sold, offered or exposed for sale which shall contain none of the above named constituents shall be exempt from the provisions of this act.

Section 2. Every manufacturer or importer of commercial fertilizers as specified in section one of this act, shall on or before the first day of January, next ensuing, or before offering them for sale in this Commonwealth, file annually with the Secretary of the State Board of Agriculture, an affidavit showing the amount of said fertilizer sold within the Commonwealth during the last preceding year, and if the said amount shall be one hundred tons or less, he shall pay to the Treasurer of the State the sum of ten dollars for each and every article of such commercial fertilizer sold within the State during the last preceding year, and if the said amount shall exceed one hundred tons and be less than five hundred tons, he or they shall pay the sum of twenty dollars as aforesaid, and if the said amount shall be five hundred tons or more, he or they shall pay the sum of thirty dollars as aforesaid. If such manufacturer or manufacturers, importer or importers, shall not have made any sales within the Commonwealth during the preceding year, he or they shall pay the sum of ten dollars as aforesaid. Every such manufacturer shall at the same time file with the Secretary of the State Board of Agriculture, a copy of the analysis required by section one of this act, and shall then be entitled to receive from the Secretary of the State Board of Agriculture, a certificate showing that the provisions of this act have been complied with: Provided, That the certificates which have been issued for the year ending July thirty-first, one thousand eight hundred and ninety-five, are hereby extended until the thirty-first day of December, one thousand eight hundred and ninety-five. (As amended by act, June 26, 1895.)

Section 3. Any person selling, offering or exposing for sale any commercial fertilizer without the analysis required by section one of this act, or with an analysis stating that it contains a larger percentage of any or more of the above named constituents than is contained therein, or for the sale of which all the provisions of section two have not been complied with, shall be guilty of a misdemeanor, and on conviction, shall forfeit a sum not less than twenty-five and not exceeding one hundred dollars for the first offense, and not less than two hundred dollars for each subsequent offense, one-half of which shall be for the use of the informer, and the remainder for the county in which the conviction is secured: Provided, Said informer be the purchaser and goods be for his own use.

Section 4. It shall be the duty of the Board of Agriculture to analyze such specimens of commercial fertilizers as may be furnished by its agents, said samples to be accompanied with the proper proof, under oath or affirmation, that they were fairly drawn; the fee for such analysis shall be determined by the executive committee of the Board, and be based upon a fixed rate for each determination, and shall in no case exceed seventy-five per centum of the usual price paid for such services, and shall be payable from the Treasury of the Commonwealth in the manner as now provided by law.

Section 5. That the money paid into the treasury under the provisions of this act shall constitute a special fund from which the cost of selecting samples, making analyses and other expenses incident to the carrying into effect the provisions of this act shall be paid: Provided, That the total amount thus expended shall in no case exceed the amount paid into the Treasury. (As amended by act, May 21, 1895.)

Section 6. The term "commercial fertilizers," as used in this act, shall be taken to mean any and every substance imported, manufactured, prepared, or sold for fertilizing or manuring purposes, except barnyard manure, marl, lime and wood ashes, and not exempt by the provisions of section one of this act.

Section 7. This act shall go into effect on and after the first day of August, one thousand eight hundred and seventy-nine.

Approved—June 28, 1879.

PREFACE.

Harrisburg, Pa., December 31, 1900.

The following report, containing all analyses of samples of Commercial Fertilizers collected by the agents of the Department of Agriculture from January 1 to December 31, 1900, is herewith presented for the information of the public.

The usual discussion by the chemist of changes in the prices of the ingredients of fertilizers, which have occurred since August 1, 1899, is also appended, together with a schedule of prices fixed for the current year.

The foot notes refer to the page where the appropriate list giving prices may be found; and farmers are urged to use these data, and compute for themselves, the value of the composition which they expect to purchase.

The attention of farmers is also called to Bulletin No. 55, prepared by Dr. Van Slyke, of the Geneva Experiment Station, N. Y., issued by this Department, on "The Composition and Use of Fertilizers." Many thousands of dollars could be saved to agricultural people in Pennsylvania if they would study carefully the facts contained in this bulletin, and make use of the information thus gained, in their practice. The Bulletin tells of:

1. Chemistry of Plants, Plant-Foods and Soils.
2. Description of Materials Used as Fertilizers.
3. Purchase and Use of Fertilizers.
4. Arithmetic of Fertilizers.
5. Average Composition and Value of Fertilizing Materials and of Farm Crops.

Some fertilizer manufacturers have been careless in sending in the names of the brands of fertilizers which they have upon the market. In some cases they use an abbreviated form, and in others they omit important words altogether. Our agents in the field, who collect samples for analysis, are expected to report the exact wording of the brand as found printed upon the sack. When this differs from that given to this office, we suppose that it is a new brand, and is therefore unlicensed. To correct this practice the following notice was sent last spring to all manufacturers who had goods licensed in Pennsylvania:

SPECIAL NOTICE.

"Manufacturers in sending in their list of brands of fertilizers sometimes use a slightly different wording on their sacks from that furnished this Department. Agents of the Department in reporting are required to copy the precise words used on the sack. If any change has been made in branding, from the designation sent to this office, we regard the brand so changed as UNLICENSED, and a separate license must be taken out.

Manufacturers are, therefore, cautioned to use the exact language in marking the sacks, that they have furnished to the Department for record."

Notwithstanding this, some have been guilty of the same neglect, this season, and this has caused a great deal of unnecessary trouble to the Department. It is hoped that hereafter manufacturers will strictly comply with the request of the Department, and register in this office the exact language used in branding the sacks.

Commercial Fertilizers are now a recognized necessity in the agriculture of Pennsylvania, and our farmers will have to post themselves as to the action of the various substances that compose them, or pay the penalty which is always exacted from ignorance. There was a time when the farmer could not know what to purchase, or how to purchase. That time is past, and if he is deceived now it is his own fault. Full information is at his disposal if he will take it and use it.

JOHN HAMILTON,
Secretary of Agriculture.

FERTILIZER VALUATIONS—1900.

The object of an official valuation of commercial fertilizers is to enable the consumer to judge approximately whether he has been asked to pay for a given brand more than the fertilizing ingredients it contains and market conditions prevailing at the time would warrant. It is clear, therefore, that no attempt is made in this valuation to indicate whether the fertilizer valued possesses a greater or less crop-producing capacity than another fertilizer; but only whether it is higher priced than another of the same general composition.

For this purpose it must be so computed as to include all the elements entering into the cost of a fertilizer as it is delivered to the consumer. These elements may be conveniently grouped as follows:

1. The wholesale cost of the ingredients.
2. The jobbers' gross profit on the sale of the ingredients; this includes office expenses, advertising, losses, etc.; for the purpose of the present computation it may be assumed that the sum of this gross profit and the wholesale cost of the ingredients, is equivalent to the retail price of the single ingredients near the wholesale markets in ton lots of original packages for cash.
3. The expense and profit of mixing: This item applies only to complete fertilizers, rock and potash, and ammoniated rock; not to dissolved or ground bone, or to dissolved rock.
4. The expense and profit of bagging.
5. Agents' commission: This item includes not only the commission proper, but every advance in price due to the sale of the goods through an agent in small quantities on time, rather than directly to the consumer in ton lots for cash.
6. Freight from the wholesale market to the point of delivery.

The valuations for 1899 were based:

1. Upon the wholesale prices from September, 1898, to March 1, 1899, of the raw materials used in fertilizer manufacture, the quotations of the New York market being adopted for all materials except acidulated phosphate rock and ground bone.
2. Upon an allowance of 20 per cent. of the wholesale prices, above mentioned, to cover jobbers' profits.

By adding the 20 per cent. allowed by jobbers' gross profit to the wholesale price of the several raw materials, the retail price in original packages at the jobbers' warehouse is obtained.

Since the amount of the several valuable fertilizing constituents in

the various raw materials is known, it is a simple matter to determine the corresponding retail value per pound of the valuable fertilizing constituents yielded by each raw material. A schedule of these pound values affords a convenient basis of computation of the value per ton of various fertilizers, whose composition is ascertained by analysis.

The values assigned, for the present, to the other elements in the cost of the fertilizer at the point of delivery are:

3. For mixing, \$1.00 per ton.

4. For bagging, \$1.00 per ton, in all cases except those in which the article was sold in original package; the cost of the package being, in such cases, included in the wholesale price.

5. For agents' commission, 20 per cent. of the cost of the goods f. o. b. at the jobbers' or mixers' warehouse.

6. For freight, \$2.00 per ton; the cost of the freight in lots of twelve tons or over, from the seaboard to Harrisburg, averaging \$1.88 per ton.

The following valuation of dissolved South Carolina rock illustrates the method:

Phosphoric acid.	Per cent.	Weight per ton.	
Soluble,	11.50	230 lbs. at 3c.	\$6 90
Reverted,	2.50	50 lbs. at 2½c.	1 25
Insoluble,	1.00	20 lbs. at 1½c.	30
			<hr/>
Retail cash value of ingredients,			\$8 45
Bagging,			1 00
			<hr/>
Cash value of goods ready for shipment,			\$9 45
Agents' commission, 20 per cent.,			1 89
Freight,			2 00
			<hr/>
Commercial value per ton,			<u>\$13 34</u>

It is not to be expected, of course, that the valuations thus computed will precisely represent the fair price to be charged for a brand in each locality and in every transaction. Market conditions, competition, distance from factory, all introduce minor variations. Nevertheless, to make the approximation reasonably close, the average valuation of a given class of goods ought to agree closely with its ascertained average selling price. Whenever such an agreement is no longer obtained by the use of a schedule, it is evident that the schedule of retail values of the constituents, or the added allowances for mixing, etc., requires revision.

It is needful to note here another factor greatly affecting the practical accuracy of these approximations. Their computation would offer little difficulty and their usefulness be far greater, if, by the ordinary methods of analysis, the exact nature of the ingredients used to supply the several fertilizer constituents, were capable of certain determination. This is, however, possible to-day to only a limited extent. The valuations are, therefore, based on the assumption that the fertilizers are uniformly compounded from high quality ingredients, such as are commonly employed in the manufacture of fertilizers of the several classes. Consumers should carefully avoid the error of accepting such valuations as infallible; they are not designed to be used for close comparison of single brands, but only to indicate whether the price asked for a fertilizer is abnormal, assuming good quality for the ingredients used. From this it is clear that, except as high freights may require, the selling price of a brand should not far exceed the valuation; but that a fertilizer may be made of inferior materials and yet have a high valuation.

The valuations used during 1897 and 1898 were modified for use during 1899 in accordance with the changes in wholesale prices of fertilizer ingredients and to make the valuations more closely follow the selling prices.

The following comparative statement shows the valuations and selling prices of the several classes of fertilizers during 1898 and 1899.

Fertilizers.	Number of samples.	Valuation.	Selling price.	Difference of valuation from selling price.
Spring, 1898.				
Complete,	379	\$26 69	\$24 46	+2 23
Alkaline,	54	15 06	15 92	-0 84
Dissolved bone,	10	25 71	23 20	+2 51
Ground bone,	55	27 82	26 25	+1 57
Dissolved rock,	82	14 59	12 80	+1 79
Fall, 1898.				
Complete,	195	24 70	22 86	+1 84
Alkaline,	50	14 79	17 02	-2 23
Dissolved bone,	9	24 70	23 17	+1 53
Ground bone,	29	28 03	27 62	+0 41
Dissolved rock,	69	13 98	13 73	+0 25
Spring, 1899.				
Complete,	250	24 53	23 60	+0 93
Alkaline,	47	15 06	16 83	-1 78
Dissolved bone,	8	21 75	21 75	0 00
Ground bone,	38	28 06	26 67	+1 39
Dissolved rock,	58	14 02	13 86	+0 66
Fall, 1899.				
Complete,	181	23 38	22 98	+0 40
Alkaline,	41	14 53	17 28	-2 75
Dissolved bone,	7	22 30	19 00	+3 30
Ground bone,	24	27 87	24 98	+2 89
Dissolved rock,	55	13 19	12 64	+0 55

These figures show that the schedule adopted for 1899 applied excellently well to the complete fertilizers and quite well to the dissolved rock, but was too high for ground bone. The mixed rock and potash goods continue to be sold at an inexplicably high rate. Comparing the spring and fall prices, a marked increase in price of the rock-and-potash goods, a slight one in those for complete fertilizers, little change in those for dissolved rock, but a very marked decrease in those for ground and dissolved bone are perceived.

The general tendencies of the wholesale market may be judged from the following comparative statement, obtained from the weekly reports of the *Oil, Paint and Drug Reporter*, of New York City, showing the average wholesale prices of fertilizer raw materials from September 1, 1898, to March 1, 1899, and from September 1, 1899, to March 1, 1900:

Wholesale Prices of Fertilizer Ingredients.

New York; *Oil, Paint and Drug Reporter*.

Substance.	Amount priced.	Average price, Sept., 1898, to March, 1899.	Average price, Sept., 1899, to March, 1900.	Prices Sept.-Feb. 1899-1900, in per cent. of prices, 1898-1899.
1. Sulphate of ammonia,	Cwt.,	\$2.6457	\$2.9730	112.3
2. Nitrate of soda,	Cwt.,	1.5763	1.7870	113.3
3. Dried blood, H. G.,	Unit (20 lbs.),	1.7629	2.0733	117.6
4. Dried blood, L. G.,	Unit (20 lbs.),	1.7229	1.8276	106.0
5. Concentrated tankage,	Unit (20 lbs.),	1.925	1.782	92.6
6. Rough bone,	Ton,	19.021	20.875	109.7
7. Ground bone,	Ton,	20.54	23.15	107.8
8. Bone meal,	Ton,	21.54	24.441	112.4
9. Fish guano (dry),	Ton,	19.087	20.816	108.5
10. Fish guano (acid),	Ton,	10.0751	11.136	110.5
11. Refuse bone-black,	Ton,	20.50	19.875	96.9
12. Phosphate rock (Charleston),	Ton,	3.50	3.75	107.1
13. Phosphate rock (Peace river),	Ton,	2.75	4.25	154.5
14. Phosphate rock (land, 70 per cent.),	Ton,	3.125	3.125	100.0
15. Acid phosphate,	Unit (20 lbs.), .....	.625	.620	99.2
16. Double manure salts,	Cwt.,	1.084	1.0387	95.8
17. Sulphate of potash,	Cwt.,	2.0102	2.0079	99.8
18. Kainit,	Ton,	9.021	9.3937	104.1
19. Muriate of potash,	Cwt.,	1.835	1.8106	98.6
20. Sulphuric acid, 66 degrees B.,	Cwt.,	1.101	1.475	123.9

In ammoniates, such as dried blood or concentrated tankage, the unit is of ammonia, of which 82.35 per cent. is nitrogen; in acid phosphates, the unit is of phosphoric acid (phosphorus pentoxid).

Confining our attention, at present, to the nitrogenous materials and animal sources of phosphoric acid, we find an advance approximating 10 per cent. all along the line, with an exception in the case of refuse bone-black and a doubtful one in case of concentrated tankage.

The following data are taken from the monthly reports of Thomas J. White & Co., fertilizer brokers, of Baltimore, Md., giving wholesale quotations upon "ammoniates:"

Wholesale Prices of Ammoniates:

Reports of Thomas J. White & Co., Baltimore, Md.

	Price, September to March, 1898-1899.	Price, September to March, 1899-1900.
Sulphate of ammonia, per cwt.—		
Foreign,	\$2 60	132 97
Domestic, gas,	2 63	12 96
Ground blood, f. o. b. Chicago, per unit of ammonia,	1 66	1 54
Concentrated tankage, f. o. b., Chicago, per unit of ammonia,	1 37	1 51
Crushed tankage, f. o. b., Chicago, per ton—		
7 per cent. ammonia, 25 per cent. bone phosphate,		13 00
8 per cent. ammonia, 20 per cent. bone phosphate,	13 60	
9 per cent. ammonia, 20 per cent. bone phosphate,	14 87	14 79
9½ per cent. ammonia, 18 per cent. bone phosphate,	\$16 00	116 44
9½ per cent. ammonia, 15 per cent. bone phosphate,	15 50	
10½ per cent. ammonia, 15 per cent. bone phosphate,		**17 20
10 per cent. ammonia, 10 per cent. bone phosphate,	††15 70	
||Crushed tankage, c. a. f. Baltimore, per unit ammonia,	††1 63	\$81 90
Hoof meal, f. o. b. Chicago, per unit ammonia,	1 42	1 58

*c. i. f. Baltimore. †c. i. f. Baltimore, quotations for December and January lacking.
 ‡f. o. l. Boston. §Quotations for September and February only. ||Quotations lacking for September and October. **Quotations for September lacking. †† Quotation for February lacking.
 ‡‡Quotation for December, January and February. §§Lacking quotations for September and January. |||Quotation per unit of bone phosphate stands unchanged at 10 cents.

Direct comparison is not possible here in all items; an advance of approximately 10 per cent. is notable in cases of ammonium sulphate, concentrated tankage and hoof-meal, a 7 per cent. decrease in that of blood, a 16 per cent. increase in the ammonia of crushed tankage c. a. f. Baltimore, with but little change in the '9 and 20' grade f. o. b. Chicago. The monthly reports show the usual stiffening of prices during the early Spring months.

The *Engineering and Mining Journal* in its review of the wholesale markets for fertilizing materials for 1899, gives the following quotations:

Review of 1899 Fertilizer Market: *Engineering and Mining Journal*.

Substance.	January.	June.	November.
Sulphate of ammonia, per cwt.—			
Gas liquor (24 to 25 per cent. ammonia),		\$2.738	*\$2.925
Bone liquor,		2.625	*2.758
Nitrate of soda, N. Y., spot, per cwt.,	\$1.587		1.725
Dried blood, per unit of ammonia—			
Western high grade,	1.862	1.850	1.725
New York,	1.887	1.875	1.835
Azotine, per unit ammonia,	1.735	1.900	1.775
Concentrated tankage, per unit ammonia, f. o. b. Chicago,	1.625	1.625	1.475
Tankage, high grade Western, f. o. b. Chicago, per ton,	14.75	17.25	14.75
Bone tankage,	19.00	20.50	20.50
Ground bone, per ton delivered,	24.25	24.25	22.50
Dried fish, per ton, f. o. b. works,	19.75	19.75	19.75
Acid fish, per ton, f. o. b. works,	11.25	10.75	10.75
Dissolved bone black (17-18 per cent. phosphoric acid),	16.25	16.25	16.25

*December instead of November quotations.

These figures clearly indicate the increased price of nitrogenous salts, but not so clearly to the casual view, the movement in the prices of animal products. The fertilizer market, like many others, is characterized by periodic intervals of special activity, so that to gain an idea of the annual fluctuations in price, an exact comparison of prices in corresponding months of the years compared, is better than a study of the variations observed within a single year. Taking the months for which the quotations are used, prices usually being quiet in November and stiffening in January, there is likewise indicated an advance in the case of New York dried blood and azotine, and a less advance in the prices of high-grade tankage and bone tankage, but a falling off in the price of bone.

Relative to the prices of raw rock phosphates: The statistics of the *Engineering and Mining Journal* exhibit a large increase in the production and export of domestic phosphate, and an increased import of the Belgian phosphate used as filler. The exports of Florida high-grade and Florida, South Carolina and Tennessee pebble rock in 1898, amounted to 580,948 long tons, invoiced at \$4,672,463 or \$8.04 per ton; those of 1899, amounted to 880,845 long tons, invoiced at \$6,994,345 or \$7.94 per ton. In January, 1899, the price of *high grade rock* (75 to 80 per cent. bone phosphate) was \$8.75 f. o. b. Fernandina; in January of this year, \$10 was considered a good selling price. In January, 1899, Florida land pebble (68 to 73 per cent. bone phosphate) was quoted at \$5.75 delivered in New York; in April to November, at \$7.08. Peace River rock sold during the year, as high as \$4.50. As to *Tennessee* rock: High-grade export (75 to 80 per cent.) sold in January at \$2.15 f. o. b. Mt. Pleasant, and later fluctuated up to \$3.90. *High grade domestic* reached \$2.50 to \$2.75 in the latter part of the

year; *low grade* (65 per cent.) was quoted at \$1.75 f. o. b. Mt. Pleasant in January, but later at \$2.25 to \$2.50.

South Carolina rock: Prices of crude rock, short ton, f. o. b. New York, were in January to March, 1899, \$5.67; in April to June, \$6.00; later f. o. b. Fettersea, \$4.37; prices of kiln-dried rock (60 per cent.) were quoted, f. o. b. Ashley, during the year, at \$3.17; and \$4.37 to \$4.75 as to quality, f. o. b. Fettersea.

These figures, like those of the *Oil, Paint and Drug Reporter*, show only slight fluctuations for South Carolina phosphates, but a distinct advance in the prices of higher-grade Florida and Tennessee phosphates.

Considering the cost of the acid used in acidulation of the soluble phosphates, and the raw materials of acid manufacture: Brimstone continues to be used at a decreasing rate, pyrites more and more replacing it in their manufacture. The reports of the U. S. Bureau of Statistics for the years ending June 30th, of 1898 and 1899, respectively, give average import value of crude brimstone of all grades as follows:

In 1898, \$17.80 per long ton; 1899, \$18.41, an advance of about 3 per cent. The report of the Bureau issued in 1899, gives lower values for the 1898 importations than those stated in the report issued in 1898. The final figures for 1899 differ little from those given in 1898, for the trade of the twelve months ending June 30 of that year. The corrected figures may be taken as showing a slightly advancing price for this commodity. The *Engineering and Mining Journal* quotes "seconds," spot New York, as follows:

January, 1899; \$21.25 to \$21.50 to \$21.50 to \$22.00; November, \$22.00, with no large fluctuations during the year. The consumption of pyrites largely increased in 1899; the production in this year was over 60 per cent. greater than in 1898. These goods were largely placed on contract and market fluctuations were of little influence. The prices of the high grade America pyrites (Pilley's Island, New Foundland, 50 per cent. sulphur), f. o. b. New York, stood at about \$6.50 per ton for lump, and \$4.50 for fines. The same authority says concerning the acid itself, that during 1899 it was bought in a larger way and more largely consumed for fertilizers. Prices in January, 1899, were: For 66° acid, 100 lb. drums, \$1.10, as against \$1 in 1898; chamber acid (50°), per ton, f. o. b. factory, in bulk, at \$11.50 to \$12, as compared with \$7.50 to \$8 in 1898. The prices fluctuated little during the next ten months, but in November and December, 1899, contracts were made for 1900 delivery at the following rates: 66°, \$1.20 per cwt.; chamber acid, 55°, at \$16 to \$17 per ton f. o. b. factory. That is, the price of chamber acid, that commonly employed in fertilizer manufacture, advanced about 33 per

cent. This corresponds to the increase shown by the quotations of the *Oil, Paint and Drug Reporter*.

The prices of the crude rock and the sulphuric acid are, however, of less direct interest than those of the acid rock phosphate. In spite of the higher quotations for sulphuric acid, and the slightly stiffening tone of the phosphate market, quotations of the acidulated rock, show practically no change up to March 1, 1900, remaining at about 62.5 cents per unit of available phosphoric acid.

The prices of German potash salts are regulated by the German Potash Syndicate. On the basis of large lots (500 tons bulk salts or 50 tons concentrated salts) sold through brokers for cash and delivered at Boston, New York or Philadelphia, the schedules announced by the Syndicate are as follows:

	Before March 31, 1899.	After March 31, 1899.	After March 1, 1900.*
Muriate (80 to 85 per cent. 80 per cent. basis), cwt.,	\$1.75	\$1.78	\$1.80 to \$1.85
Sulphate (90 per cent. 90 per cent. basis), per cwt.,	1.965	1.985	2.025 to 2.065
Double manure salt (48 to 50 per cent., 48 per cent. basis), per cwt.,	1.005	1.025	1.04 to 1.065
Kainit, per ton,	8.70	8.90	8.90 to 9.30

*Prices vary according to point of delivery. These prices show an advance of about 3 per cent. over those of 1899 in case of concentrated salts.

Another element affecting prices has been the reorganization of the trade by the formation of several large combinations of fertilizer producers, especially the American Agricultural Chemical Company in the North, and the Virginia-Carolina Chemical Company in the South. The *Engineering and Mining Journal*, speaking of the trade conditions, says: "The year 1899 realized better profits to the manufacturer than 1898, notwithstanding the increased cost of raw materials. The trade has been kept well in hand by the two largest combinations. There was a good export business in ammoniates. The outlook for 1900 is for higher prices. The cost of manufacture will likely be \$1.50 to \$2.50 per ton over that of 1899 because of the upward movement of raw materials.

Composition of Raw Materials.

In order to form a correct idea of the cost per pound of the fertilizing constituents of these materials, it is needful to determine their

composition; or, in other words, the quantities of valuable materials each contains. With the exception of ground bone and dissolved rock phosphates, very few of the single ingredients of fertilizers have been analyzed in Pennsylvania during the past year; in the following table, the averages include the results of analyses made in Massachusetts, Connecticut, New Jersey and Pennsylvania, except in the case of ground bone and dissolved rock phosphates, where Pennsylvania results alone have been included.

Composition of Non-Acidulated Fertilizer Ingredients (Per Cent).

	Number of samples analyzed.	Nitrogen.	Potash.	Total phosphoric acid.
Sulphate of ammonia,	3	20.52	.....	.....
Nitrate of soda,	26	15.65	.....	.....
Dried blood,	8	13.03	.....	.....
Ground bone,	62	3.23	.....	22.89
Tankage,	21	6.06	.....	13.23
Ground fish,	23	7.87	.....	7.00
Cottonseed meal,	23	7.14	1.90	3.15
Castor pomace,	8	5.56	1.02	2.02
Sulphate of potash, high grade,	11	.....	48.96	.....
Muriate of potash,	44	.....	50.57	.....
Kainit,	10	.....	12.98	.....
Double sulphate of potash and magnesia,	8	.....	27.16	.....

Composition of Acidulated Fertilizer Ingredients (Per Cent).

	Number of samples analyzed.	Total phosphoric acid.	Soluble phosphoric acid.	Reverted phosphoric acid.	Insoluble phosphoric acid.
Dissolved bone-black,	12	17.34	15.09	1.86	.39
Dissolved bone,	15	13.73	5.15	5.25	3.33
Dissolved rock phosphate,	113	15.98	9.64	4.72	1.61

*Also contains 1.52 per cent. of nitrogen.

Considering simply those materials sold by the hundred weight or the ton, rather than by the unit, there is found a little less nitrogen in the sulphate of ammonia, ground fish, cotton-seed meal and dissolved bone than was exhibited in last years' analyses; a little more phosphoric acid in the bone and tankage, but less in the acidu-

lated goods; the muriate of potash contained a little less actual potash, but the kainit and double manure salts a little more. Such variations are to be expected.

Cost per Pound of Fertilizer Constituents.

From the foregoing data showing the cost per ton, hundred-weight, or other unit of measure, of the several raw materials, and the quantities of valuable constituents the average materials now on the market contain, the wholesale cost per pound of the valuable constituents can be readily estimated. In the case of ammoniates, the quotations are "per unit of ammonia" in many cases. The term "unit" is equivalent to "per cent.;" in goods sold by the ton of 2,000 lbs., the unit is equal to 20 lbs.; and 20 lbs. of ammonia contains 16.47 lbs. of nitrogen.

- In the case of refuse bone-black, unacidulated, the mean, 28.25 per cent. of phosphoric acid, is assumed to represent the average material on the market.

Phosphate rock is sold by the ton of 2,240 lbs.; this material is sold on the basis of the bone-phosphate of lime it contains, with drawbacks for injurious constituents.

The Charleston rock is understood to contain 60 per cent. of bone phosphate; the land rock, 70 per cent.; in the absence of a reliable average for the Peace River rock quoted, no attempt is made to include it in this estimate. Since bone phosphate of lime contains 45.8 per cent. of phosphoric acid, each per cent. of bone phosphate in a long ton of phosphate rock is equivalent to 22.4 lbs. and contains 10.26 lbs. of phosphoric acid.

In the wholesale trade, it is customary to sell dried blood, azotine, horn and hoof meals, and concentrated tankage solely on the basis of ammonia, to the entire disregard of the phosphoric acid contained.

Likewise, the insoluble phosphoric acid in dissolved rock is omitted from consideration, and contracts are based solely upon the "available" phosphoric acid; that is, the sum of the "soluble" and "reverted" or "citrate soluble" phosphoric acid; nor in rock phosphates is any claim made for the small quantities of nitrogen and potash they always contain, nor in dissolved bone for the potash present.

Under these conditions, the wholesale cost per pound in New York of the valuable constituents of such materials as furnish but a single fertilizing element, these materials being assumed to be in the state of preparation and in the package in which the manufacturer purchased them, are given in the following table; also, a figure representing a fair retail price at the factory, the materials having undergone no change in treatment or packing, and the allowance for expense and profit in retailing being 20 per cent.

Wholesale Cost per Pound of Fertilizer Constituents (New York).

I. Ingredients Supplying One Constituent.

Constituent Valued.		Wholesale price.	Wholesale price plus 20 per cent.
		Cents.	Cents.
Sulphate of ammonia,	Nitrogen,	14.49	17.38
Nitrate of soda,	Nitrogen,	11.42	13.70
Dried blood, high grade,	Nitrogen,	10.36	12.43
Dried blood, low grade,	Nitrogen,	9.14	10.87
Concentrated tankage,	Nitrogen,	8.91	10.69
Refuse bone-black,	Phosphoric acid, total,	3.52	4.22
Charleston rock,	Phosphoric acid, total, .....	.61	.73
Land rock,	Phosphoric acid, total, .....	.44	.53
Acid phosphate,	Phosphoric acid, available,	3.10	3.72
Dissolved bone-black,	Phosphoric acid, available,	4.79	5.75
Double manure salts,	Potash,	3.82	4.58
Sulphate of potash,	Potash,	4.10	4.92
Muriate of potash,	Potash,	3.58	4.30
Kainit,	Potash,	3.61	4.33

The quotations for bone are given without reference to quality, so that it is impossible from these data to fairly apportion their several wholesale values to the nitrogen and the phosphoric acid contained in this material. As compared with tankage, the general tendency is to assign a higher commercial rating to the phosphoric acid in bone and to the nitrogen a rating not very different from that given in tankage.

The quotations of Thos. J. White & Co., show the average wholesale rates in Baltimore during September, 1899 to March, 1900, for tankage, crushed, to have been \$1.90 per unit of ammonia and \$0.10 per unit of bone phosphate of lime; this is equivalent to \$2.31 per unit of nitrogen and \$0.218 per unit of phosphoric acid.

The average composition of the ground bone and bone meal samples analyzed in Pennsylvania, last Fall, was as follows:

Phosphoric acid, 22.48 per cent.; nitrogen, 3.33 per cent.

The prepared bone contains less fat and moisture, and often less nitrogen than the ordinary "rough bone;" but these differences tend, in a manner, to neutralize each other.

Assuming for the rough bone quoted in the New York markets the same composition as the bone meal sold in Pennsylvania, and for the value of the nitrogen, \$2.31 per unit, the values per pound of the several constituents would be:

Wholesale Cost, per Pound, of Fertilizer Constituents (New York).

II. Bone.

	Constituent Valued.	Wholesale price.	Wholesale price plus 20 per cent.
		Cents.	Cents.
Rough bone,	Nitrogen,	11.5	13.8
	Phosphoric acid,	2.93	3.52
Ground bone,	Nitrogen,	12.20	14.64
	Phosphoric acid,	3.11	3.73

There are no wholesale data available for the direct estimation of the wholesale pound values of acidulated bone (animal bone); the schedule must, upon this point, depend upon retail selling prices.

The prices paid by farmers' fertilizer associations may be regarded as semi-wholesale. The quantities are considerable and the terms of payment often more favorable to the manufacturer than is the case with agents' transactions.

With this understanding, they furnish an excellent check upon the values computed from the price-lists of trade journals. Through the courtesy of various officials, the writer is in possession of the prices quoted in a number of these transactions for the Spring of 1900, which give the following pound values for the several constituents bought.

Prices per Pound of Fertilizer Ingredients Quoted to Fertilizer Purchasing Associations.

Constituent Valued.	Material by which It Is Supplied.	Pennsylvania.	New Jersey.
		Cents.	Cents.
Nitrogen,	Sulphate of ammonia,	14.80	15.27
	Nitrate of soda,		11.86
	Dried blood,		13.93
	Tankage,		11.99
Phosphoric acid,	Dried fish,		16.15
Potash,	Acid phosphate,	2.93	3.70
	Double manure salt,	5.00	5.00
	Sulphate of potash, high grade,		4.48
	Muriate of potash,	3.96	3.79
	Kalnit,	4.58	4.12

Judging from these figures, the New Jersey associations are buying at a little lower rates than those in Pennsylvania, although there may be differences in the conditions unknown to the writer, that will satisfactorily account for the difference in price. The prices quoted are in some instances higher and in some lower than the wholesale price plus 20 per cent

VALUATIONS IN NEIGHBORING STATES.

It is desirable, from all points of view, that the schedules of valuation throughout a district in which similar market conditions prevail, should differ as little as possible. It has been our practice in the past, to conform our schedule to that adopted after very careful co-operative study of market conditions for each year, by the New England states and New Jersey, except where the peculiar conditions of our market have made the valuations diverge too largely from the actual selling prices, as in the case of ground bone and dissolved rock phosphates.

The New England schedules for 1899 and 1900 are as follows:

Trade Values Adopted by the New England States and New Jersey.

Ingredients.	Cents per Lb.		Values of 1900 in per cent. of values of 1899.
	1899.	1900.	
Nitrogen—			
In ammonia salts,	15	17	113.3
In nitrates,	12½	13½	108.0
In dry and fine-ground fish,	14	15½	110.7
In meat, blood and mixed fertilizers,	14	15½	110.7
In fine-ground bone and tankage,	14	15½	110.7
In coarse bone and tankage,	10	10½	105.0
Phosphoric acid—			
Water soluble,	4½	4½	100.0
Citrate soluble,	4	4	100.0
In cotton-seed meal, castor-pomace, and wood ashes,	4	4	100.0
In dry, fine-ground fish, bone and tankage,	4	4	100.0
In coarse fish, bone and tankage,	2	2	150.0
In mixed fertilizers, insoluble,	2	2	100.0
Potash—			
In forms free from muriate (chlorid),	5	5	100.0
As muriate,	4½	4½	100.0

The pound values assigned to the several constituents of nitrogen salts, ammoniates, acid phosphate and potash salts are clearly in accordance with the wholesale market conditions from September, 1899, to March, 1900, as shown by the quotations of the *Oil, Paint and Drug Reporter*, relative to those for the corresponding period of the preceding year. As to ground bone, assuming an average fineness of 70 per cent. fine and 30 per cent. coarse, the average value for nitrogen in ground bone according to the New England schedule is 13.4 cents per pound and for phosphoric acid, 3.7 cents per pound. In this schedule, the nitrogen value is somewhat lower than that deduced

from the average composition of Pennsylvania bone and the market quotations.

Upon a careful consideration of the changes and tendencies of the wholesale prices of fertilizer ingredients and of the discrepancies occurring since the adoption of the 1899 schedule of valuation, it has been decided that the schedule for use during 1900 should be the same as that adopted for the use of New Jersey and New England except at three points.

1. In the values assigned to water-soluble and citrate-soluble phosphoric acid derived from bone and other animal matter: for reasons mentioned last year, the Pennsylvania schedule allowed one-half cent more per pound for these ingredients than did the New England schedule. Since February, 1899, as foregoing tables show, the prices of rough bone and sulphuric acid have increased, though the quotations for phosphoric acid in crushed tankage and for refuse bone-black have not materially altered. To adopt the New England schedule for 1900 and apply it to the average complete fertilizer analysed in the last Fall season, would yield a valuation of \$22.77 as compared with a selling price of \$22.98. To thus lower the valuation in the face of a rising market is not believed to be wise. Our valuations of 1899 will, therefore, be retained during 1900 for the water-soluble and citrate-soluble phosphoric acid of animal origin.

2. For reasons fully discussed in 1897, it is needful to include in the Pennsylvania schedule of valuations, a distinct set of values for phosphoric acid derived from rock as contrasted with that derived from animal materials. Reference to the tables, given on an earlier page, showing the wholesale cost of a pound of phosphoric acid, will make it plain that when it comes from phosphate rock, it costs the fertilizer maker about one-half a cent; when from refuse bone-black, as quoted in New York, 3.5 cents; when from tankage, about 1.1 cents; and from bone, 2.93 cents. There is nothing to indicate that, after acidulation, the available phosphoric acid from bone is at all better for the crop than that from a good rock lime-phosphate. But so long as the consumer is persuaded that bone phosphoric acid is worth more for his crop than an equal weight of rock phosphoric acid, just so long will the manufacturer of fertilizers be able to command a higher price for fertilizers reputed to derive their phosphoric acid from bone, and just so long will he, in turn, be obliged to pay more for it on the wholesale market. Now, in some states, the volume of rock phosphoric acid used is relatively small and the need for its separate valuation not apparent; in other states it predominates to the almost entire exclusion of bone phosphoric acid, so that no distinct valuation for the latter is required; but in Pennsylvania both occupy important positions upon the market and each requires its own set of values. Despite the

slightly upward tendency of the acid phosphate market, it is thought needless to change the valuations of these constituents at this time, because the average valuations have, under the existing schedule, considerably exceeded the actual selling prices.

3. For similar reasons, nitrogen and phosphoric acid in ground bone are valued at lower rates in Pennsylvania than in New England. Some margin of excess of valuation over selling price still being maintained during the fall of 1899, no increase in the pound values for the constituents of this ingredient seems necessary. This margin is about 10 per cent. over the average selling price during the Fall of 1899, an amount fully equivalent to the higher price of bone to March 1, as exhibited by the quotations of the *Oil, Paint and Drug Reporter*.

Tankage is scheduled with bone, though costing less, because it is little sold at retail.

The schedule for 1900, as a whole, is as follows:

Schedule of Values for Fertilizer Ingredients, 1900.

	Cents per lb.
Nitrogen, in ammonia salts,	17
in nitrates,	13½
in dry and fine ground fish, meat and blood, and in mixed fertilizers,	15½
in cotton-seed meal and castor pomace,	15½
in fine bone and tankage,	10
in coarse bone and tankage,	8½
Phosphoric acid, soluble in water, in bone fertilizers,	5
soluble in water, in rock fertilizers,	3
soluble in ammonium citrate, in bone fer- tilizers,	4½
soluble in ammonium citrate, in rock fer- tilizers,	2½
insoluble in ammonium citrate, in bone fer- tilizers,	2
insoluble in ammonium citrate, in rock fer- tilizers,	1½
Phosphoric acid in fine bone, tankage and fish,	3½
Phosphoric acid in coarse bone and tankage,	2
Phosphoric acid in cotton-seed meal, castor pomace and wood ashes,	4½
Potash in high grade sulphate and in form free from muriate (or chlorid),	5
as muriate,	4½

Potash in excess of that equivalent to the chlorin present, will be valued as sulphate, and the remainder as muriate.

Nitrogen in mixed fertilizers will be valued as derived from the best sources of organic nitrogen, unless clear evidence to the contrary is obtained.

Phosphoric acid in mixed fertilizers is valued at bone phosphoric acid prices, unless clearly found to be derived from rock phosphate.

Bone is sifted into two grades of fineness: Fine, less than $\frac{3}{16}$ inch in diameter; coarse, over $\frac{3}{16}$ inch in diameter.

The result obtained by the use of this schedule does not cover the items of mixing, bagging, freight and agents' commission. To cover these, allowances are made as follows:

For freight, an allowance of \$2.00 per ton on all fertilizer.

For bagging, an allowance of \$1.00 per ton on all fertilizers, except when sold in original packages.

For mixing, an allowance of \$1.00 per ton on complete fertilizers, and rock-and-potash goods.

For agents' commission, an allowance of 20 per cent. is added to the cash values of the goods ready for shipment.

The mean quotations on freight from New York, Philadelphia and Baltimore to Harrisburg, in January, 1897, was \$1.68 per ton, in lots of twelve tons or over; in May, 1899, quotations by the Pennsylvania Railroad were: From New York, \$2.40; from Philadelphia, \$1.70; and from Baltimore, \$1.55; mean rate from the three points, \$1.88.

FERTILIZER ANALYSES, JANUARY 1 TO AUGUST 1, 1900.

During the six months ending July 1, 1900, there were received from the several authorized sampling agents six hundred and seventy-seven (677) fertilizer samples, of which four hundred and fifteen (415) were subjected to analysis, the remainder being rejected, either because they represented brands that were analyzed last season, or because they were regarded as not certainly representative of the brand which they purported to represent. In case of brands represented by two or more samples, portions from the several samples were united and the composite sample was subjected to analysis.

The samples analyzed group themselves as follows: 276 complete fertilizers, furnishing phosphoric acid, potash and nitrogen; 2 dissolved bones, furnishing phosphoric acid and nitrogen; 48 rock-and-potash fertilizers, furnishing phosphoric acid and potash; 30 ground

bones, furnishing phosphoric acid and nitrogen; 56 acidulated rock phosphates, furnishing phosphoric acid only three miscellaneous fertilizers, which group includes potash salts, nitrate of soda and other substances not readily classified under the foregoing heads.

The determinations to which a complete fertilizer is subjected are as follows: (1) Moisture, useful for the comparison of analyses, for indication of dry condition and fitness for drilling, and also of the conditions under which the fertilizer was kept in the warehouse. (2) Phosphoric acid—total, that portion soluble in water, and that portion not soluble in warm ammonium citrate solution (a solution supposed to represent the action of plant roots upon the fertilizer), and the portion insoluble, which is assumed to have little immediate food value. By difference, it is easy to compute the so-called "reverted" acid, which is the portion insoluble in water but soluble in the citrate. The sum of the soluble and reverted is commonly called the "available" phosphoric acid. (3) Potash soluble in water,—most of that present in green sand marl and crushed minerals, and even some of that present in vegetable materials such as cotton-seed meal, not being included because insoluble in water even after long boiling. (4) Nitrogen—this element is determined by a method which simply accounts for all present, without distinguishing between the quantities present in the several forms of ammonium salts, nitrates or organic matter. (5) Chlorin; this determination is made to afford a basis for estimating the proportion of the potash that is present as chlorid or muriate, the cheaper source. The computation is made on the assumption that the chlorin present, unless in excess, has been introduced in the form of muriate of potash; but doubtless there are occasional exceptions to this rule. One part of chlorin combines with 1.326 parts of potash to form the pure muriate; knowing the chlorin, it is, therefore, easy to compute the potash equivalent thereto. (7) In the case of ground bone, the state of sub-division is determined by sifting through accurately made sieves; the cost of preparation and especially the promptness of action of bone in the soil depends very largely on the fineness of its particles, the finer being much more quickly useful to the plant.

The law having required the manufacturer to guarantee the amount of certain valuable ingredients present in any brand he may put upon the market, chemical analysis is employed to verify the guarantees stamped upon the fertilizer sacks. It has, therefore, been deemed desirable in this report to enter the guaranty filed by the manufacturer in the office of the Secretary of Agriculture, in such connection with the analytical results that the two may be compared. An unfortunate practice has grown up among manufacturers of so wording the guaranty that it seems to declare the presence in the goods of an amount of a valuable constituent ranging from a certain minimum to

a much higher maximum; thus, "Potash, 2 to 4 per cent.," is a guaranty not infrequently given. In reality, the sole guaranty is for 2 per cent. The guaranteed amounts given for each brand in the following tables, are copied from the guaranties filed by the maker of the goods with the Secretary of Agriculture, the lowest figure given for any constituent being considered to be the amount guaranteed. For compactness and because no essentially important fact is suppressed thereby, the guaranties for soluble and reverted phosphoric acid have not been given separately, but are combined into a single guaranty for available phosphoric acid; in cases where the maker's guaranty does not specifically mention available phosphoric acid, the sum of the lowest figures given by him for soluble and reverted phosphoric acid is used. The law allows the maker to express his guaranty for nitrogen either in terms of that element or in terms of the ammonia equivalent thereto; since ammonia is composed of three parts of hydrogen and fourteen parts of nitrogen, it is a very simple matter to calculate the amount of one, when the amount of the other is given; the amount of nitrogen multiplied by 1.214 will give the corresponding amount of ammonia, and the amount of ammonia multiplied by 0.824 will give the corresponding amount of nitrogen. In these tables, the expression is in terms of nitrogen. Many manufacturers after complying with the terms of the law, insert additional items in their guaranties, often with the result of misleading or confusing the buyer; the latter will do well to give heed to those items only that are given as the law requires and that are presented in these tables.

A summary of the analyses made this season may be presented as follows:

Summary of Analyses Made this Season.

	Complete fertilizers.	Dissolved bone.	Rock and potash.	Dissolved rock.	Ground bone.
Number of analyses,	276	2	48	56	30
Moisture, per cent.,	9.06	4.09	10.52	9.59	5.96
Phosphoric acid—					
Total, per cent.,	10.55	14.22	12.52	15.87	21.45
Soluble, per cent.,	4.83	1.19	5.98	9.44	.....
Reverted, per cent.,	5.52	5.11	4.88	4.83	.....
Insoluble, per cent.,	2.20	7.92	1.66	1.60	.....
Potash, per cent.,	3.74	.....	2.43	.....	.....
Nitrogen,	1.77	4.55	.....	.....	2.96
Mechanical analysis of bone—					
Fine, .....	.....	.....	.....	.....	73
Coarse, .....	.....	.....	.....	.....	27
Commercial valuation,	24.61	20.87	14.71	13.48	25.91
Average selling price,	25.33	24.00	17.35	13.57	23.42
Commercial value of samples whose selling price is ascertained,	24.59	26.26	14.71	13.49	25.31

The cases of departure of goods from their guaranteed composition observed this season, including only those cases in which it amounted to two-tenths per cent, or more, were as follows:

	Complete fertilizers.	Dissolved bone.	Rock and potash.	Dissolved rock.	Ground bone.
Deficient in four constituents,	4				
Deficient in three constituents,	3		1		
Deficient in two constituents,	33		3		
Deficient in one constituent,	71	1	16	2	2
Total samples in which deficiency occurred, .	116	1	14	2	11

The cases of deficiency noted during the past three seasons in the goods as compared with their several guarantees, expressed in percentage of the total number of goods of each class analyzed are as follows:

	Spring, 1899.	Fall, 1899.	Spring, 1900.
Complete fertilizers,	38.4	33.7	42.0
Dissolved bone,	50.0	14.3	*50.0
Rock-and-potash,	19.1	34.2	29.2
Dissolved rock,	13.8	14.5	5.4
Ground bone,	18.4	25.3	35.7
All classes except miscellaneous,	30.9	29.2	35.2

*Only two samples analyzed.

The following comparisons of actual selling prices and the valuations based upon market conditions of the wholesale market for the six months preceding March 1 of the current year is of much interest. It indicates a considerable increase in the gross profit of the manufacturers and dealers during the past season as compared with that of 1899.

	Selling price.	Valuation.	Excess of selling price over valuation.
Complete fertilizers—			
1899, Spring,	23.60	24.70	—1.10
1899, Fall,	22.98	23.42	— .44
1900, Spring,	25.38	24.61	.77
Dissolved bone—			
1899, Spring,	21.75	21.81	— .06
1899, Fall,	19.00	21.12	—2.12
*1900, Spring,	26.00	30.87	—4.87
Rock-and-potash—			
1899, Spring,	16.83	15.16	1.67
1899, Fall,	17.28	14.53	2.75
1900, Spring,	17.35	14.71	2.64
Dissolved rock—			
1899, Spring,	13.36	14.03	— .67
1899, Fall,	12.64	13.13	— .49
1900, Spring,	13.57	13.48	.09
Ground bone—			
1899, Spring,	26.67	28.11	—1.44
1899, Fall,	24.98	27.23	—2.25
1900, Spring,	28.42	25.91	2.51

*Only two samples analyzed.

ANALYSES OF SPRING SAMPLES.

TABULATED ANALYSES OF COMMERCIAL FERTILIZERS

FROM

SAMPLES SELECTED BY SPECIAL AGENTS

OF THE

PENNSYLVANIA DEPARTMENT OF AGRICULTURE.

Analyses by DR. WILLIAM FREAR, Chemist of the Department, and of the State College Experiment Station, State College, Pa.

SAMPLES SELECTED FROM JAN. 1, 1900, TO AUG. 1, 1900.

COMPLETE

Furnishing Phosphoric Acid,

Sample number.	Manufacturer and Brand.	From Whom Sample Was Taken.	
	ALLEGHENY CITY FERTILIZER WORKS, ALLE- GHENY, PA.		
524	Pure Potato Manure,	P. C. Steiner, Bakerstown,	
	ALLENTOWN MANUFACTURING CO., ALLEN- TOWN, PA.		
227	{ Complete Bone Phosphate,	{ Edward J. Unangst, Nazareth, }	
189			Callahan & Weaver, Montoursville,
588			Harrison Saul, New Tripoli,
190	H. G. Potato Phosphate,	Callahan & Weaver, Montoursville,	
186	H. G. Truck Phosphate,	Callahan & Weaver, Montoursville,	
187	{ Special \$25 Phosphate,	{ Callahan & Weaver, Montoursville, }	
238			Edward J. Unangst, Nazareth,
	AMERICAN REDUCTION CO., PITTSBURGH, PA.		
325	{ Iron City,	{ Horn & Hoover, Atlantic, }	
513			W. H. Heckert, Bakerstown,
519			W. H. Heckert, Bakerstown,
338	{ Vegetable Manure,	{ A. L. Ingols & Son, Norrisville, }	
672			Bryan Bros., Scottdale,
	ARMOUR FERTILIZER WKS, CHICAGO, ILLI- NOIS.		
499	All Soluble,	Hansman & Rockel, Rittersville,	
607	Bone, Blood & Potash,	W. H. Diehl, Northumberland,	
336	{ Grain grower,	{ J. F. Patton, Hartstown, }	
411			E. A. Slagle, Paxinos,
441			Jno. F. Chisholm, Sterrettania,
87			J. L. Ritter & Son, Newport,
498			Hansman & Rockel, Rittersville,
529		Geo. L. Moore, Brownsville,	
537		J. Hoffman & Son, Jenners,	

For explanation of these tables see p. 27. †Composite sample.

FERTILIZERS.

Potash and Nitrogen.

Moisture in 100 pounds.	Phosphoric Acid in 100 Pounds.								Potash in 100 Pounds. (Water Soluble.)				Nitrogen in 100 pounds.		Computed commercial value of 2,000 pounds at Department rating. (See p. 26.)	Selling price of 2,000 pounds at the point of selection.	Sample number.
	Soluble in water.	Reverted.	Insoluble.	Total.		Available.		Present as muriate.	Present as sulphate.	Total.		Found.	Guaranteed.				
				Found.	Guaranteed.	Found.	Guaranteed.			Found.	Guaranteed.						
4.60	3.95	3.85	3.86	11.48	9.00	*7.80	8.00	8.42	.....	8.42	7.00	*2.00	2.50	31.00	28.00	534	
8.77	3.79	4.94	4.72	*13.45	14.00	*8.73	9.00	4.44	.....	4.44	4.00	1.83	1.50	27.99	30.00	237	
7.77	2.67	5.53	2.31	*11.56	13.00	8.25	8.00	.....	6.91	*6.91	7.00	2.31	1.50	32.05	30.00	189	
4.81	2.50	5.53	8.21	*11.24	13.00	8.03	8.00	.....	2.66	2.66	2.00	3.02	3.00	31.51	23.00	586	
7.85	4.30	7.54	3.74	15.58	15.00	11.84	11.00	2.00	.56	2.56	2.00	1.03	.50	26.13	35.00	190	
9.73	4.73	3.17	1.62	*9.52	10.00	*7.90	9.00	2.24	.....	2.24	2.00	2.86	2.47	27.18	25.00	186	
8.79	3.25	2.16	1.40	6.81	.....	*5.41	6.00	6.32	.....	6.92	6.00	3.22	2.45	30.25	25.00	157	
5.69	2.10	6.21	1.82	10.13	9.50	8.31	8.00	.....	5.34	5.34	4.00	3.28	2.88	33.20	25.00	238	
5.70	7.76	2.25	.43	10.44	10.00	10.01	8.00	.....	7.20	7.20	7.00	*3.58	4.11	33.38	22.00	439	
8.23	5.26	3.76	2.74	11.76	9.50	9.02	8.00	2.39	.....	2.39	2.00	1.77	1.65	25.04	24.00	518	
															24.00	519	
															.....	17.00	673

For explanation of these tables see p. 27. †Composite sample.

COMPLETE FERTI

Sample number.	Manufacturer and Brand.	From Whom Sample Was Taken.
527 606 413 56 523	{ †H. G. Potato Fertilizer, †Wheat, Corn and Oats Special, }	{ Geo. L. Moore, Brownsville, W. H. Diehl, Northumberland, E. A. Slagle, Paxinos, J. L. Ritter & Son, Newport, Geo. L. Moore, Brownsville, }
R. S. AUCKER, SHAMOKIN, PA.		
301 298 410 300 299	Grade B Bone & Slaughter House Phosphate, Grade C Bone & Slaughter House Phosphate, H. G. Bone & Slaughter House Phosphate, Pure Bone Meal with Potash, Special Potato, Truck & Tobacco Phosphate,	Geo. R. Hendricks, Sellinsgrove, Geo. R. Hendricks, Sellinsgrove, R. S. Aucker, Shamokin, Geo. R. Hendricks, Sellinsgrove, Geo. R. Hendricks, Sellinsgrove,
BALTIMORE PULVERIZING CO., BALTIMORE, MD.		
665 289 664 663	Special Corn Mixture, †Special Potato Mixture,—S. P. M., Spring Mixture,	A. J. Duchanols, Frenchtown, H. J. Hoffman, Jenners, A. J. Duchanols, Frenchtown, A. J. Duchanols, Frenchtown,
BAUGH & SONS CO., PHILADELPHIA, PA.		
106 297 296 106 674 104 295 15 675 294 18 14	Corn Fertilizer, Corn Fertilizer for Sugar Corn & Garden Truck, ... †Double Eagle Phosphate, †General Crop Grower for all Crops, Potato Fertilizer, Special Potato Manure, ‡25 Phosphate,	J. U. Ruff, New Oxford, Peter Fink, Somerset, Peter Fink, Somerset, J. U. Ruff, New Oxford, A. Gaddis & Co., Uniontown, J. U. Ruff, New Oxford, Peter Fink, Somerset, C. Frank Williamson, Media, A. Gaddis & Co., Uniontown, Peter Fink, Somerset, C. Frank Williamson, Media, C. Frank Williamson, Media,

For explanation of these tables see p. 27. †Composite sample.

LIZERS—Continued.

Moisture in 100 pounds.	Phosphoric Acid in 100 Pounds.							Potash in 100 Pounds. (Water Soluble.)				Nitrogen in 100 pounds.		Computed commercial value of 2,000 pounds at Department rating. (See p. 2c.)	Selling price of 2,000 pounds at the point of selection.	Sample number.
	Soluble in water.	Reverted.	Insoluble.	Total.		Available.		Present as muriate.	Present as sulphate.	Total.		Found.	Guaranteed.			
				Found.	Guaranteed.	Found.	Guaranteed.			Found.	Guaranteed.					
6.75	4.20	4.65	1.62	10.47	9.50	8.85	8.00	4.33	4.49	9.02	4.00	1.71	1.64	31.56	31.00	527
														32.00	606	
														33.00	413	
7.50	3.15	5.36	3.71	12.22	8.50	8.51	7.00	1.77	.....	1.77	1.00	1.08	.82	21.63	30.00	86
														20.00	523	
6.70	3.73	3.74	2.48	*9.95	10.39	*7.47	8.13	3.60	.....	3.60	3.55	*.93	1.20	21.34	23.00	301
6.17	3.46	4.46	2.24	10.10	10.14	*7.92	8.45	3.27	.....	3.27	2.60	*.82	.96	20.73	21.50	298
6.91	4.61	5.19	3.41	13.21	12.61	*9.80	10.11	2.95	.....	*2.95	3.03	*1.89	1.95	27.25	23.00	410
6.02	3.13	6.20	3.21	14.54	17.00	6.33	.....	4.57	.....	4.57	4.00	2.60	2.47	29.53	26.00	300
4.22	3.32	3.65	2.26	9.23	9.00	*6.97	7.00	6.21	.....	6.21	6.00	*1.54	3.29	25.54	30.00	299
4.72	2.05	4.11	1.77	7.93	.....	6.16	.....	3.03	.....	3.03	.....	.77	.....	18.12	23.00	663
8.50	.64	4.25	1.10	5.99	.....	4.89	.....	4.91	.....	4.91	.....	1.63	.....	21.45	22.30	389
7.31	1.55	5.72	1.65	8.92	.....	7.27	.....	2.21	.....	2.21	.....	.68	.....	18.06	.....	664
9.19	3.86	5.02	1.71	10.59	.....	8.88	8.00	.47	.....	.47	.....	*1.48	1.65	21.33	21.00	106
10.63	5.24	3.77	1.22	10.23	.....	9.01	8.00	.91	.....	.91	.....	2.03	1.65	23.94	22.90	397
														22.00	396	
11.07	5.06	3.90	2.34	11.32	.....	8.98	8.00	1.34	.....	1.34	1.00	1.77	1.65	23.70	24.00	105
														18.00	674	
														18.00	104	
														18.00	395	
8.55	5.75	3.12	1.36	10.26	.....	8.90	8.00	.....	2.04	2.04	1.00	1.19	.82	22.23	22.00	15
														19.00	675	
1.27	4.30	4.43	2.26	11.04	.....	8.78	8.00	2.32	.....	2.32	2.00	1.78	1.65	24.55	23.00	394
3.65	3.52	4.37	1.33	10.07	.....	8.69	5.00	6.80	4.03	10.83	10.00	1.71	1.65	33.00	30.00	16
11.35	5.07	3.43	3.31	10.80	.....	8.49	8.00	.....	1.89	1.89	1.00	*1.41	1.65	22.78	25.00	14

*Constituent falls below guarantee.

COMPLETE FERTI

Sample number.		
	Manufacturer and Brand.	From Whom Sample Was Taken.
	WM. F. BAUGHMAN, RINELY, PA.	
125	Ammoniated Bone Phosphate,	Wm. F. Baughman, Woodline,
124	Harvest Queen Phosphate,	Wm. F. Baughman, Woodline,
126	Potato & Tobacco Phosphate,	Wm. F. Baughman, Woodline,
	BERG CO., PHILADELPHIA, PA.	
231	Special Potato Guano,	Jno. Goheen, Birdsboro,
	BERGER BROS., EASTON, PA.	
432	Lehigh Super Phosphate,	W. S. Weaver, Easton,
433	Peerless Phosphate,	W. S. Weaver, Easton,
239	Potato and Truck,	Frank Gerner, Nazareth,
	A. H. BLAKER & CO., FOX CHASE PA.	
65	} †Special for General Use,	Wm. Eyre, Newtown,
433		C. P. Wotring, Unionville,
66	Special for Potatoes,	Wm. Eyre, Newtown,
472	} †Special for Wheat & Corn,	Geo. W. Westcott, Oxford,
492		C. P. Wotring, Unionville,
474	Poudrette,	Geo. W. Westcott, Oxford,
	BOWKER FERTILIZER CO., BOSTON & NEW YORK.	
375	} †Ammoniated Dissolved Bone,	Alvin Sax, Effort, Pa.,
452		L. Clark, Waterford,
153	} †Farm & Garden Phosphate,	Bailey & Converse, Wellsboro,
423		J. H. Case, Danville,
183	Market Garden,	J. R. Hood, Colton,
453	Potash Bone,	L. Clark, Waterford,
151	} †Potash or Staple,	J. R. Hood, Colton,
351		Osro Wykoff, Woodcock,
132	Potato & Vegetable Phosphate,	J. R. Hood, Colton,
222	} †6 per cent. Potato Fertilizer,	J. A. Heckman, Shanersville,
152		Bailey & Converse, Wellsboro,
671		Loucks, Morrow & Co., Scottdale,

For explanation of these tables see p. 27. †Composite sample.

LIZERS—Continued.

Moisture in 100 pounds.	Phosphoric Acid in 100 Pounds.						Potash in 100 Pounds. (Water Soluble.)				Nitrogen in 100 pounds.		Computed commercial value of 2,000 pounds at Department rating. (See p. 25.)	Selling price of 2,000 pounds at the point of selection.	Sample number.	
	Soluble in water.	Reverted.	Insoluble.	Total.		Available.		Present as muriate.	Present as sulphate.	Total.		Found.				Guaranteed.
				Found.	Guaranteed.	Found.	Guaranteed.			Found.	Guaranteed.					
12.28	1.37	5.70	1.97	*9.04	11.00	*7.07	9.00	2.58	.....	2.58	2.00	*.94	1.33	19.36	23.00	125
21.57	1.65	5.88	1.70	9.23	9.00	*7.53	8.00	2.16	.....	2.16	2.00	*.70	.32	18.37	20.00	124
15.75	3.01	4.87	2.35	*10.23	11.00	*7.88	9.00	3.02	.....	*3.02	4.00	*1.34	1.65	22.51	23.00	126
9.20	4.28	3.38	2.60	10.26	.....	*7.06	8.00	9.90	.....	9.90	8.00	*2.78	3.29	24.95	40.00	231
12.11	5.73	4.00	1.90	11.63	9.50	9.73	8.50	5.34	.....	*5.34	5.50	*1.57	1.64	27.76	28.50	482
6.82	2.82	5.89	1.41	10.12	10.00	8.71	8.00	2.37	.....	2.37	2.00	.99	.82	20.92	18.00	483
10.23	5.40	2.74	1.77	9.91	9.00	8.14	8.00	5.58	.....	*5.86	6.00	*3.51	3.69	33.68	23.50	229
8.58	6.49	3.44	2.03	11.96	9.00	9.93	8.00	1.82	.....	*1.82	2.00	1.27	1.00	23.38	25.00	63
8.90	6.19	3.56	1.24	*10.99	11.00	*9.75	10.00	8.41	.....	8.41	8.00	1.05	1.00	23.76	30.00	66
7.98	5.66	2.98	1.47	10.11	8.00	8.04	7.00	1.63	.....	1.63	1.00	.93	.75	20.34	21.00	472
10.62	3.63	2.98	.82	7.43	5.00	6.61	4.00	2.32	.....	2.32	1.00	*.57	.75	16.81	20.00	492
14.61	6.85	4.11	1.86	12.82	.....	10.90	8.00	2.06	.....	2.06	1.00	1.35	1.00	25.05	26.00	375
11.73	7.20	3.69	2.51	13.30	.....	10.79	8.00	2.27	.....	2.27	2.00	1.55	1.50	26.19	28.00	452
11.66	3.96	2.57	1.96	8.49	.....	6.53	6.00	10.19	.....	10.19	10.00	3.03	2.25	34.64	35.00	153
10.11	1.00	5.36	2.73	9.09	7.00	6.36	6.00	1.20	1.43	2.63	2.00	.91	.82	19.02	30.00	423
11.87	5.97	4.09	2.17	12.23	9.00	10.06	8.00	3.79	.....	3.79	3.00	.82	.82	23.91	25.00	181
14.57	7.46	8.06	1.85	12.37	10.00	10.52	9.00	2.48	.....	2.48	2.00	*1.63	1.65	26.23	24.00	351
11.51	5.06	3.96	2.27	11.29	.....	9.02	7.00	6.32	.....	6.32	6.00	.90	.75	25.62	28.00	233
															30.00	152
															32.36	671

*Constituent falls below guarantee.

COMPLETE FERTI

Sample number.	Manufacturer and Brand.		From Whom Sample Was Taken.	
424	Stockbridge Manure,		J. H. Case, Danville,	
	BRADLEY FERTILIZER CO., BOSTON, MASS.			
622	{ †Bean & Potato Phosphate,	{	Grier & Osterhout, Punxsutawney,	{
517			S. J. Saint, Sharpsburg,	
609			L. H. Davison & Son, Franklin,	
403			N. J. Beachey, Elk Lick,	
328	{ †Niagara Phosphate,	{	A. F. Stutzman, Johnstown,	{
436			Robt. Stebbins, Moslertown,	
516			S. J. Saint, Sharpsburg,	
515			S. J. Saint, Sharpsburg,	
424	{ †Sea Fowl Guano,	{	Robt. Stebbins, Moslertown,	{
543			G. B. Mills, N. Towanda,	
	S. B. BRODBECK, BRODBECK'S, PA.			
116	Reliable,		Sheffer & Frey, Hanover,	
	BRUMFIELD & FOSTER, COLORA, MD.			
280	Hard Times,		R. F. Schwarz, Spragueville,	
282	Potato Phosphate,		R. F. Schwarz, Spragueville,	
281	Special Tomato & Potato,		R. F. Schwarz, Spragueville,	
	CAMBRIA FERTILIZER CO., JOHNSTOWN, PA.			
312	B. & B. Phosphate,		H. A. Shoemaker, Ebensburg,	
313	{ †Standard Phosphate,	{	H. A. Shoemaker, Ebensburg,	{
506			M. A. Zimmerman, Critchfield,	
	CHEM. CO. OF CANTON, BALTIMORE, MD.			
481	Amomniated Bone Phosphate,		Morris Nauman, Stroudsburg,	
42	Baker's Fish Guano,		Jacob S. Beshore, Newberrytown,	
523	{ †Baker's Standard H. G. Guano,	{	W. H. Heckert, Bakerstown,	{
601			W. A. Leiser, Watsontown,	
278			S. F. Miller, Mechanicsburg,	
636			H. M. Gray, Tyrone,	
534	Eagle Phosphate,		J. Specht, Kantner,	
260	Game Guano,		J. A. Romberger, Elizabethtown,	

For explanation of these tables see p. 27. †Composite sample.

LIZERS—Continued.

Moisture in 100 pounds.	Phosphoric Acid in 100 Pounds.								Potash in 100 Pounds. (Water Soluble.)				Nitrogen in 100 pounds.		Computed commercial value of 2,000 pounds at Department rating. (See p. 25.)	Selling price of 2,000 pounds at the point of selection.	Sample number.
	Soluble in water.	Reverted.	Insoluble.	Total.		Available.		Present as muriate.	Present as sulphate.	Total.		Found.	Guaranteed.				
				Found.	Guaranteed.	Found.	Guaranteed.			Found.	Guaranteed.						
9.96	5.29	2.45	2.18	9.92	7.00	7.74	6.00	9.37	.....	*9.37	10.00	2.90	3.29	34.77	40.00	424
7.32	5.46	3.88	1.01	10.35	10.00	9.34	8.00	3.35	.....	*3.88	4.00	.90	.32	22.96	30.00	622
															24.00	517	
															29.00	669	
															33.00	403	
8.15	2.53	5.99	1.52	10.34	8.00	8.52	7.00	1.19	.....	1.19	1.00	.90	.62	19.38	22.00	328
															21.00	435	
															20.00	516	
															25.00	515	
9.25	4.52	3.97	2.47	10.96	10.00	8.49	8.00	1.89	.....	1.89	1.50	2.10	2.05	25.06	26.00	424
															32.00	568	
9.26	5.05	3.73	1.35	10.13	.....	8.78	.....	2.41	.....	2.41	.....	.84	.....	20.78	19.00	116
9.80	5.02	3.57	2.25	10.84	.....	8.59	.....	2.13	.....	2.13	.....	1.05	.....	21.49	22.00	390
7.95	3.76	3.87	3.70	11.33	.....	7.03	.....	5.03	.....	5.03	.....	1.23	.....	24.69	25.00	382
11.66	6.02	2.75	2.43	11.20	.....	8.77	.....	10.46	.....	10.46	.....	1.59	.....	32.36	32.00	381
4.34	1.59	2.81	1.50	*6.20	8.00	*4.70	6.50	2.72	.....	2.72	2.00	1.01	1.00	16.90	20.00	312
7.47	5.34	2.76	1.59	9.69	7.00	8.10	6.00	4.02	.....	4.02	3.00	*1.70	2.50	24.97	25.00	312
															25.00	506	
7.97	5.44	3.97	2.25	10.66	10.00	8.41	8.00	2.22	.....	2.22	2.00	1.30	1.23	22.29	25.00	481
12.67	5.82	2.72	1.62	10.16	10.00	8.54	8.00	2.49	.....	2.49	2.00	*1.54	1.65	23.43	23.00	42
6.72	3.40	4.21	2.18	*9.79	10.00	*7.61	8.00	3.91	.....	3.91	3.00	*1.88	2.06	25.12	24.00	523
															24.00	601	
7.92	5.06	2.50	1.34	*9.20	10.00	*7.86	8.00	5.63	.....	*5.63	6.00	*1.93	2.06	27.21	32.00	278
															35.00	636	
10.06	1.79	5.45	2.62	9.89	8.00	7.27	7.00	1.64	.....	1.64	1.00	.86	.82	18.60	20.00	534
8.52	5.61	2.42	.57	*8.00	10.00	8.03	8.00	2.73	.....	2.73	2.00	*1.58	1.65	22.80	23.00	260

*Constituent falls below guarantee.

45-7-1900

COMPLETE FERTI

Sample number.	Manufacturer and Brand.	From Whom Sample Was Taken.
77	{ †Potato Manure, }	J. W. Hostettler, Walnut, }
133		R. B. Hyson, Bridgeton, }
236		Thos. Smoyer, Bath, }
303		N. B. Winey, Middleburg, }
41		Jacob S. Beshore, Newberrytown, }
480		Morris Nauman, Stroudsburg, }
522		W. H. Heckert, Bakerstown, }
637	H. M. Gray, Tyrone, }	
640	H. L. Stultz, Duncansville, }	
277	Resurgam Guano,	S. F. Miller, Mechanicsburg,
CHICOPEE GUANO CO., NEW YORK.		
285	Farmer's Reliable Corn & Wheat Mixture,	Thomas Worman, Bath,
53	Farmer's Reliable Potato, Corn & Wheat Mixture,	E. B. Hickman, & Sons, West Chester,
234	Standard Guano for Vegetables,	Thomas Worman, Bath,
CLARK'S COVE FERTILIZER CO., NEW YORK.		
506	King Philip Alkaline Guano,	C. I. & J. H. Way, Coleman's, }
270	{ †King Philip, }	A. Cameron Bobb, Paxinos, }
573		Fowler Ellis, Franklindale, }
507	{ †Potato & Hop Grower, }	C. I. & J. H. Way, Coleman's, }
269		A. Cameron Bobb, Paxinos, }
572		Fowler Ellis, Franklindale, }
E. FRANK COE CO., NEW YORK.		
48	Empire State Brand,	D. E. Brown, E. Berlin,
100	Famous Red Brand Excelsior Guano,	D. E. Brown, E. Berlin,
98	Western New Yorker,	D. E. Brown, E. Berlin,
243	XXV Ammoniated Bone Super Phosphate,	Wm. H. Mengel, Saylorsburg,
HENRY COPE & CO., LINCOLN UNIVERSITY, PA.		
222	Pennsylvania Wheat Grower and Complete Ma- nure,	Wilson & Mendenhall, Toughkenamon,
477	Special Chester Co. Potato & Corn Phosphate, ...	Henry Cope & Co., Oxford,

For explanation of these tables see p. 27. †Composite sample.

LIZERS—Continued.

Moisture in 100 pounds.	Phosphoric Acid in 100 Pounds.								Potash in 100 Pounds. (Water Soluble.)				Nitrogen in 100 pounds.		Computed commercial value of 2,000 pounds at Department rating. (See p. 25.)	Selling price of 2,000 pounds at the point of selection.	Sample number.
	Soluble in water.	Reverted.	Insoluble.	Total.		Available.		Present as muriate.	Present as sulphate.	Total.		Found.	Guaranteed.				
				Found.	Guaranteed.	Found.	Guaranteed.			Found.	Guaranteed.						
7.55	2.40	3.72	2.46	8.58	7.00	6.12	6.00	4.97	.....	*4.97	5.00	1.33	1.23	22.59	22.00	77
															23.00	132	
															25.00	236	
															20.00	303	
															23.00	41	
															23.00	480	
															24.00	522	
															27.00	637	
															27.00	640	
8.54	4.82	3.52	1.14	*9.51	10.00	8.37	8.00	3.39	.....	*3.89	4.00	*.72	.82	21.14	24.00	277
9.25	3.88	3.58	1.82	9.25	8.00	7.40	7.00	1.24	.....	1.24	1.00	.90	.83	18.45	22.00	235
11.06	4.67	3.30	1.98	9.93	8.00	7.97	7.00	1.53	.....	1.53	1.00	.95	.83	19.63	21.00	53
12.02	5.14	3.79	2.03	10.96	9.00	8.93	8.00	2.87	.....	*3.57	4.00	.90	.83	22.62	25.00	234
11.15	5.36	2.94	2.46	10.76	9.00	8.30	8.00	2.13	.....	2.13	2.00	1.14	1.02	21.67	24.00	506
11.82	6.79	3.25	1.05	11.09	9.00	10.04	8.00	2.16	.....	2.16	2.00	1.16	1.02	23.06	23.00	270
															24.00	573	
															28.00	507	
7.59	4.08	3.63	2.31	10.02	8.00	7.71	6.00	4.59	.....	*4.59	5.00	1.24	1.23	23.66	22.00	269
															26.00	572	
9.50	7.38	2.01	1.52	*10.91	16.00	9.39	8.00	.67	3.26	*3.93	4.00	*1.55	1.53	26.55	26.00	43	
8.10	8.34	1.46	.81	10.61	.....	9.80	.....	.....	5.95	5.95	.....	3.11	.....	35.05	33.00	100
7.34	5.82	2.80	2.95	*11.57	16.00	8.02	8.00	.....	4.30	4.30	4.00	.97	.80	24.50	24.00	93
13.50	6.23	3.21	2.66	12.15	.....	9.49	.....	1.44	.....	1.44	.....	.81	.....	21.14	20.00	243
10.32	3.56	5.74	2.39	10.69	8.00	8.30	7.00	4.15	.....	4.15	4.00	1.30	1.23	24.09	25.00	223
5.26	2.26	4.71	2.02	*8.99	9.00	*6.97	8.00	4.24	.....	4.24	4.00	1.48	1.23	23.07	24.00	477

*Constituent falls below guarantee

COMPLETE FERTI

Sample number.	Manufacturer and Brand.	From Whom Sample Was Taken.
	CROCKER FERTZ. & CHEM. CO., BUFFALO, N. Y.	
512	Ammoniated Wheat & Corn Fertilizer,	J. H. Thompson, Harmerville,
326	Complete Manure,	J. M. Harshberger & Sons, Johnstown,
513	New Rival Ammoniated Super Phosphate,	J. H. Thompson, Harmerville,
665	Special Potato Manure,	Chas. Stoltz, Meadville,
428	Universal Grain Grower,	C. R. Forbes, Albion,
	E. DARON, DOVER, PA.	
288	Harvest King Bone Phosphate,	E. Daron, Dover,
	DETRICK FERTILIZER & CHEM. CO., BALTI-MORE, MD.	
521	Ammoniated Bone Phosphate,	W. H. Heckert, Bakerstown,
544	Paragon Ammoniated Bone Phosphate,	Levi Berkey, Somerset,
520	} †Standard Potash Fertilizer,	W. H. Heckert, Bakerstown,
530		T. L. Butter, Confluence,
208	Corn & Oats Fertilizer,	Passmore & Gillisple, Nottingham,
	JAS. G. DOWNWARD & CO., COATESVILLE, PA.	
49	} †Ammoniated Bone Phosphate,	Jas. G. Downward & Co., Newtown Square,
54		Thomas Agnew, Kelton,
148	Royal Bone Phosphate,	J. T. L. Hare, Flemington,
50	} †Special Potato Fertilizer,	Jas. G. Downward & Co., Newtown Square,
149		J. T. L. Hare, Flemington,
	EUREKA FERTILIZER CO., PERRYVILLE, MD.	
136	} †Corn & Potato Special,	C. T. Grove, Felton,
212		Kirk & Yerkes, Nottingham,
137	} †Fish, Rock and Potash,	C. T. Grove, Felton,
214		Kirk & Yerkes, Nottingham,
7	Potato & Vegetable Fertilizer,	Londongrove Grange, Chatham,
	WASHINGTON EWING, LANDENBURG, PA.	
211	Waste Land Potato Phosphate,	Passmore & Gillisple, Nottingham,
	R. C. FAIRLAMB & SON, BRANDYWINE SUMMIT, PA.	
11	Corn Special Phosphate,	R. C. Fairlamb & Son, Brandywine Summit,

LIZERS—Continued.

Moisture in 100 pounds.	Phosphoric Acid in 100 Pounds.								Potash in 100 Pounds. (Water Soluble.)				Nitrogen in 100 pounds.		Computed commercial value of 2,000 pounds at Department rating. (See p. 25.)	Selling price of 2,000 pounds at the point of selection.	Sample number.
	Soluble in water.	Reverted.	Insoluble.	Total.		Available.		Present as muriate.	Present as sulphate.	Total.		Found.	Guaranteed.				
				Found.	Guaranteed.	Found.	Guaranteed.			Found.	Guaranteed.						
7.40	7.80	1.63	1.75	11.18	9.00	9.43	8.00	1.98	.....	1.98	1.50	*1.92	2.05	25.50	24.00	512
8.90	5.14	3.31	1.15	9.60	9.00	8.45	8.00	3.80	.....	*3.80	4.00	*.80	.82	21.55	27.00	326
8.75	8.64	2.57	1.83	13.03	10.00	11.21	9.00	2.08	.....	2.08	2.00	1.30	1.23	25.44	24.00	513
10.07	6.96	2.35	.68	9.98	9.00	9.30	8.00	6.67	.75	7.42	7.00	*3.10	3.23	34.83	40.00	665	
7.52	4.45	3.39	.88	*8.72	9.00	*7.84	8.00	2.11	.....	2.11	2.00	1.10	.82	20.06	25.00	438
6.70	5.20	3.36	1.83	10.39	10.00	*8.56	9.00	5.34	.....	5.34	5.00	*1.13	1.65	24.90	22.00	288
7.10	5.84	3.61	2.18	11.03	9.00	9.45	7.00	2.25	.....	2.25	1.00	1.19	.82	23.12	22.00	521
7.04	.70	5.13	3.60	9.43	9.00	*5.83	7.00	1.42	.....	1.42	1.00	.87	.82	17.13	17.50	544
6.52	1.23	5.31	2.53	9.12	7.00	6.59	6.00	5.38	.....	5.38	5.00	*1.10	1.23	22.86	24.00	520
7.42	6.52	3.10	1.06	10.68	10.00	9.02	9.00	.67	2.45	3.12	3.00	.96	.82	23.25	23.00	208	
5.86	2.75	4.36	3.17	10.31	.....	7.14	.....	3.05	.....	3.05	.....	.92	.....	20.43	24.00	49
7.46	3.85	5.26	3.04	12.15	.....	9.11	.....	2.96	.....	2.96	.....	.98	.....	22.89	27.00	148
5.38	2.50	4.37	3.35	10.22	.....	6.87	.....	3.85	.....	3.85	.....	1.31	.....	22.47	27.00	50
															33.00	149	
8.86	4.44	3.56	1.71	*9.71	11.00	*8.00	9.00	1.93	.....	*1.93	3.00	*.53	.82	13.44	20.00	136
															21.00	212	
9.68	3.80	4.54	2.38	10.72	9.00	8.34	8.00	1.78	.....	1.78	1.00	*.39	.41	13.33	16.00	137
9.30	5.47	3.52	3.26	12.25	10.00	8.99	8.00	3.04	.....	*3.04	4.00	*1.43	1.65	25.40	21.00	1
10.03	5.19	3.73	3.62	12.54	5.00	8.92	3.00	3.26	.....	3.26	2.00	1.44	1.23	25.14	24.00	211
7.28	6.90	2.41	.89	10.20	.....	9.31	8.00	1.73	2.42	4.15	3.00	*1.52	1.65	25.95	24.00	11

*Constituent falls below guarantee.

COMPLETE FERTI

Sample number.		
	Manufacturer and Brand.	From Whom Sample Was Taken.
10	Potato Special Phosphate,	R. C. Fairlamb & Son, Brandywine Summit, ..
	FARMER'S FERTILIZER CO., WESTMINSTER, MD.	
287	No. 1 Bone Phosphate,	Cook, Bents & Co., Dillsburg,
26	XX Bone Phosphate,	M. H. Bents, Mountain Top,
	W. S. FARMER & CO., BALTIMORE, MD.	
45	Harvest Queen,	Jacob Conley, Etters,
46	Standard Phosphate,	Jacob Conley, Etters,
	GREAT EASTERN FERTILIZER CO., RUTLAND, VT.	
420	†English Wheat Grower,	Robt. H. Morris, Danville,
63		H. C. Moyer, Perkaskie,
568		M. A. Cramer, Monroeton,
421		Robt. H. Morris, Danville,
251		John Engle, Hummelstown,
460	†Vegetable, Vine & Tobacco Fertilizer,	Sam'l Hibbs, Langhorne,
565		M. A. Cramer, Monroeton,
	GRIFFITH & BOYD, BALTIMORE, MD.	
196	Cereal Bone Plant Food,	John Artley, Muncy,
121	Farmer's Improved Phosphate,	A. M. Bechtel, Gitt's Run,
80	†Farmer's Potato Manure,	Wm. Kipp, Millerstown,
27		A. K. Straley, Hall,
197		Jno. Artley, Muncy,
81	†Peerless Fertilizer,	Wm. Kipp, Millerstown,
120		A. M. Bechtel, Gitt's Run,
30		A. K. Straley, Hall,
191	†Valley Fertilizer,	Callahan & Weaver, Montoursville,
409		E. A. Slagle, Paxinos,
28		A. K. Straley, Hall,
196		Jno. Artley, Muncy,

For explanation of these tables see p. 27. †Composite sample.

LIZERS—Continued.

Moisture in 100 pounds.	Phosphoric Acid in 100 Pounds.								Potash in 100 Pounds. (Water Soluble.)				Nitrogen in 100 pounds.		Computed commercial value of 2,000 pounds at Department rating. (See p. 26.)	Selling price of 2,000 pounds at the point of selection.	Sample number.
	Soluble in water.	Reverted.	Insoluble.	Total.		Available.		Present as muriate.	Present as sulphate.	Total.		Found.	Guaranteed.				
				Found.	Guaranteed.	Found.	Guaranteed.			Found.	Guaranteed.						
9.75	8.60	2.03	.78	11.41	.....	10.63	8.00	.93	6.73	*7.00	10.00	*1.43	1.65	31.72	27.09	10
9.30	7.50	2.33	1.49	11.32	11.00	9.83	9.00	2.46	.....	2.46	2.00	*1.59	2.06	25.05	22.50	287
10.65	6.94	2.54	1.52	11.00	.....	9.48	9.00	2.88	.....	2.88	2.50	.85	.82	22.35	13.06	25
11.31	7.41	3.14	1.79	12.34	11.50	10.55	10.00	2.67	.....	2.67	2.50	*1.17	1.23	24.54	21.06	45
11.02	7.78	2.87	1.40	12.05	11.50	10.65	10.00	2.51	.....	2.51	2.50	2.45	2.17	29.19	24.00	46
8.73	5.36	2.99	2.38	10.73	9.00	8.35	8.00	2.21	.....	2.21	2.00	.86	.82	20.62	23.00	420
															.....	63
															19.00	566	
															30.00	421	
10.25	5.69	3.09	2.32	11.10	9.00	8.78	8.00	3.80	.....	3.80	3.25	*2.00	2.05	27.01	25.00	251
															28.00	460	
															23.00	565	
9.75	5.54	2.41	.88	*9.13	10.00	8.25	8.00	2.56	.....	2.56	2.00	.97	.85	20.59	24.00	135
13.11	4.41	3.62	1.79	9.82	9.00	8.03	7.00	2.44	.....	2.44	1.50	*.68	.85	19.53	18.00	121
9.15	3.90	3.76	3.35	11.01	9.00	*7.06	8.00	9.44	.....	9.44	9.00	.95	.85	27.92	25.00	80
															27.00	27	
															32.00	197	
															15.00	51	
															15.00	120	
12.00	4.29	4.43	1.90	10.62	9.00	8.72	8.00	2.34	.....	2.34	2.00	.27	.....	13.22	16.00	30
															17.00	191	
															16.00	409	
9.31	4.30	3.71	2.07	10.08	8.00	8.01	7.00	2.95	.....	2.95	1.00	.47	.41	18.69	18.00	28
															19.00	196	

*Constituent falls below guarantee.

COMPLETE FERTI

Sample number.		
	Manufacturer and Brand.	From Whom Sample Was Taken.
	HANOVER BONE FERTILIZER CO., LTD., HANOVER, PA.	
101	Farmer's Crop Winner,	Sam'l H. Duncan, Abbotstown,
102	Hanover Blood and Bone Compound,	Sam'l H. Duncan, Abbotstown,
139	Hanover Excelsior Combine,	Lebernigh & Ferree, Red Lion,
	S. M. HESS & BRO., PHILADELPHIA, PA.	
140	Special Corn Manure,	Dan'l Spangler, Red Lion,
	F. H. HEWETT & SON, SCRANTON, PA.	
551	Odorless Lawn Dressing,	Footo & Shear Co., Scranton,
	HUBBARD & CO., BALTIMORE, MD.	
407	Farmer's Super Phosphate,	A. Cameron Bobb, Paxinos,
	M. P. HUBBARD & CO., BALTIMORE, MD.	
143	Farmer's Old Economy,	Jonathan Geesey, Dallastown,
	INTERNATIONAL SEED CO., ROCHESTER, N. Y.	
458	The International Potato & Truck Manure,	George Smith, Bristol,
	JARECKI CHEMICAL CO., SANDUSKY, OHIO.	
109	{ †Fish & Potash Potato & Tobacco Food, } { †Lake Erie Fish Guano, } { †O. K. Fertilizer, }	Eugene Burnett, Utica, }
446		Chas. M. Hershey, Kearsarge, }
539		A. B. Shaffer, Jenners, }
656		C. Mitchell & Son, Mill Village, }
443		P. F. Cutter, West Green, }
657		C. Mitchell & Son, Mill Village, }
	KEYSTONE CHEMICAL FERTILIZER CO., PHILADELPHIA, PA.	
72	Keystone Cereal Bone Phosphate,	Frank D. Duffield, Langhorne,
	LACKAWANNA FERTILIZER & CHEM. CO., MOOSIC, PA.	
454	Admiral Dewey,	Z. A. Brace, Waterford,
649	Big Yield,	W. A. Stafford, Franklin Corners,

For explanation of these tables see p. 27. †Composite sample.

LIZERS—Continued.

Moisture in 100 pounds.	Phosphoric Acid in 100 Pounds.								Potash in 100 Pounds. (Water Soluble.)				Nitrogen in 100 pounds.		Computed commercial value of 2,000 pounds at Department rating. (See p. 25.)	Selling price of 2,000 pounds at the point of selection.	Sample number.
	Soluble in water.	Reverted.	Insoluble.	Total.		Available.		Present as muriate.	Present as sulphate.	Total.		Found.	Guaranteed.				
				Found.	Guaranteed.	Found.	Guaranteed.			Found.	Guaranteed.						
8.05	5.96	2.68	1.28	9.92	8.00	8.64	7.00	2.06	.....	2.00	1.50	.67	.41	19.57	18.00	101
8.57	6.10	2.78	1.24	10.12	9.00	8.88	8.00	2.11	.....	2.11	2.00	*.66	.82	19.87	22.00	102
7.87	6.71	2.71	1.89	11.31	10.00	9.42	9.00	3.02	.....	3.02	3.00	2.00	1.65	26.77	25.00	129
9.72	5.83	3.54	2.08	11.40	9.00	9.37	8.00	2.21	.....	2.21	2.00	*.81	.82	21.44	24.00	140
6.45	3.18	4.16	4.68	12.02	.....	7.34	.....	5.55	.....	5.55	.....	2.11	.....	28.44	35.00	551
8.20	6.77	2.83	1.38	10.98	.....	9.00	8.00	2.45	.....	2.45	1.75	*1.51	1.65	24.33	24.00	407
8.94	4.80	4.53	.66	9.99	.....	9.33	.....	1.33	.....	1.33	.....	.51	.....	18.63	18.00	143
11.90	5.26	3.64	1.43	10.33	9.00	8.90	8.00	6.62	.....	*6.62	7.00	1.32	1.25	26.91	27.00	453
10.15	5.52	4.79	1.56	11.87	9.00	10.31	8.00	.93	3.49	4.42	4.00	.94	.82	25.59	23.00	169	
															25.00	446	
13.20	7.58	3.53	2.00	13.11	11.00	11.11	10.00	1.48	.....	1.48	1.00	*1.39	1.65	25.00	24.00	539
															26.00	656	
7.00	2.87	4.07	1.57	8.51	7.00	6.94	6.00	.87	.....	.87	.50	.50	.41	15.73	.....	448
															16.00	657	
8.71	6.81	1.23	2.00	10.04	.....	8.04	8.00	4.80	.58	5.38	5.00	1.73	1.65	27.01	31.00	72
6.17	2.97	2.90	1.87	8.24	7.00	6.87	6.00	.40	.74	1.14	1.00	.98	.85	17.89	20.00	454	
6.06	4.50	2.63	1.70	8.83	8.00	7.13	6.00	.93	2.58	*3.51	5.00	2.27	2.00	25.90	.....	649

*Constituent falls below guarantee.

COMPLETE FERTI

Sample number.	Manufacturer and Brand.	From Whom Sample Was Taken.
431 591 359	{†Bone Super Phosphate, Special Manure, LAZARETTO GUANO CO., BALTIMORE, MD.	{M. Schlosser, Saegerstown, Jno. A. Kuntz, Mosierville, Luther Schloch, Stone Church,
111 133 135	{†Ammoniated Bone Phosphate, Retriever Animal Bone Fertilizer, LISTER'S AGR'L CHEM. WORKS, NEWARK, N. J.	{Z. H. Cashman, New Oxford, Grove & Uffelman, Brogueville, Grove & Uffelman, Brogueville,
459 433 463 654 655	{†Ammoniated Dissolved Bone Phosphate, Celebrated Corn Manure, Corn & Potato Fertilizer,	{Frank D. Duffield, Langhorne, J. A. Frouitz, Saegertown, Harry Y. Pickering, Yardley, E. G. Culbertson, Edinboro, E. G. Culbertson, Edinboro,
107 300 44 463 497 584 483 582 633	{†Harvest Queen Phosphate, †No. 2 Corn, Potato Manure,	{John H. Hersh, New Oxford, S. L. Stryker, Petersburg, E. K. Frazer, Goldsboro, Harry Y. Pickering, Yardley, DeLong & Gackenbach, Schnecksville, .. Kachl & Griffith, Reading, David Sterner, Allentown, Pa., Kachel & Griffith, Reading, E. G. Culbertson, Edinboro,
208 457 106 292 96 310 653	{†Potato No. 2 Fertilizer, †Special Crop Producer, Special Fertilizer for Corn,	{Frank D. Duffield, Langhorne, David Sterner, Allentown, John Hersh, New Oxford, E. S. Brooks, York, Joseph Burkholder, Hummelstown, S. L. Stryker, Petersburg, E. G. Culbertson, Edinboro, David Sterner, Allentown,

For explanation of these tables see p. 27. †Composite sample.

LIZERS—Continued.

Moisture in 100 pounds.	Phosphoric Acid in 100 Pounds.								Potash in 100 Pounds. (Water Soluble.)				Nitrogen in 100 pounds.		Computed commercial value of 2,000 pounds at Department rating. (See p. 25.)	Selling price of 2,000 pounds at the point of selection.	Sample number.
	Soluble in water.	Reverted.	Insoluble.	Total.		Available.		Present as muriate.	Present as sulphate.	Total.		Found.	Guaranteed.				
				Found.	Guaranteed.	Found.	Guaranteed.			Found.	Guaranteed.						
7.25	6.83	3.88	1.26	*11.07	12.00	10.71	10.00	1.60	.40	2.00	2.00	*1.49	1.65	25.08	26.00 25.50 25.00	431	
6.71	6.01	2.84	1.54	*10.39	12.00	*8.85	10.00	2.40	3.81	*6.21	6.50	*2.24	2.50	30.81		591	
8.92	4.35	4.84	1.53	10.72	9.00	9.19	8.00	2.25	.....	2.25	2.00	*.78	.82	20.85	19.00 18.00	111
8.70	6.11	3.81	4.89	14.81	13.50	9.92	9.00	4.25	.....	4.25	4.00	2.04	1.85	30.14		133
7.02	6.53	3.25	2.50	12.28	11.00	9.78	9.00	2.05	.....	2.05	1.50	*1.78	1.81	25.76	26.00 25.00	135
12.75	6.24	1.94	2.22	10.40	.....	8.18	.....	7.35	.....	7.35	.....	3.41	.....	35.22		459
11.00	4.63	4.24	3.62	12.49	9.00	8.87	8.00	3.19	.....	3.19	3.00	*1.52	1.65	25.15	25.00 24.00	433
12.02	7.07	3.01	2.86	12.94	11.50	10.08	9.50	1.30	.83	2.08	2.00	1.25	1.24	24.49		462	
11.64	7.97	2.37	2.62	12.96	12.00	10.34	9.25	3.07	.93	4.00	4.00	*1.60	1.51	28.36	30.00 30.00	44	
13.32	6.81	1.89	2.05	10.75	8.50	8.70	7.50	6.77	.....	*6.77	7.00	*3.30	3.70	34.76		463
9.47	8.03	2.81	2.22	13.06	12.00	10.84	9.25	3.47	.67	4.14	4.00	*1.71	1.81	28.82	31.00 30.00	488	
7.30	3.91	3.57	2.26	9.74	8.00	7.48	7.00	1.43	.....	1.43	1.00	.94	.82	19.06		584
10.50	5.43	5.83	3.08	12.34	9.00	9.26	8.00	3.16	.....	3.16	3.00	*1.58	1.65	25.74	26.00 25.00 21.00	497
																584	
																488	
																532	
																653	
																303	
																487	
																108	
																232	
																96	
																310	
																652	
																439	

*Constituent falls below guarantee.

COMPLETE FERTI

Sample number.	Manufacturer and Brand.	From Whom Sample Was Taken.	
293	{ †Special Potato Fertilizer	{ E. S. Brooks, York, }	
578			{ John L. Dain, White Bear, }
67			{ R. D. Conover, Newtown, }
577	{ †Special 10 per cent. Potatoes,	{ Jno. L. Dain, White Bear, }	
204	Standard Pure Bone Super Phosphate of Lime,	Frank D. Duffield, Langhorne,	
485	{ †Standard Super Phosphate of Lime,	{ David Sterner, Allentown, }	
496			{ De Long & Gackenbach, Schnecksville, .. }
583			{ U. S. Super Phosphate,
499	Vegetable Compound,	Kachel & Griffith, Reading,	
		David Sterner, Allentown,	
MAPES FORMULA & PERUVIAN GUANO CO., NEW YORK.			
465	Average Soil Complete Manure,	Swartley Bros. & Co., Doylestown,	
377	{ †Complete Manure "A" Brand,	{ R. F. Schwarz, Spragueville, }	
466			{ Swartley Bros. & Co., Doylestown, }
378			{ R. F. Schwarz, Spragueville, }
558	{ †Corn Manure,	{ C. P. Wells, Towanda, }	
266	{ †Economical Potato Manure,	{ Jno. L. Nissley, Middletown, }	
379			{ R. F. Schwarz, Spragueville, }
464			{ Swartley Bros. & Co., Doylestown, }
262	{ †Potato Manure,	{ Jno. L. Nisley, Middletown, }	
553	{	{ Jas. Layton, Tunkhannock, }	
557			{ Tobacco Manure Wrapper Brand,
253	{ †Vegetable Manure,	{ Jno. L. Nissley, Middletown, }	
554			{ Jas. Layton, Tunkhannock, }
MARYLAND FERTILIZER CO., BALTIMORE, MD.			
646	Ammoniated Bone,	W. A. Nickodemus, Curry,	
308	Amomniated Fertilizer O. K.,	Jno. G. Simpson, Huntingdon,	
MILLER FERTILIZER CO., BALTIMORE, MD.			
286	Special Potato Fertilizer,	S. N. Bailey & Bro., Dillsburg,	
285	W. G. Phosphate,	S. N. Bailey & Bro., Dillsburg,	

For explanation of these tables see p. 27. †Composite sample.

LIZERS—Continued.

Moisture in 100 pounds.	Phosphoric Acid in 100 Pounds.								Potash in 100 Pounds. (Water Soluble.)				Nitrogen in 100 pounds.		Computed commercial value of 2,000 pounds at Department rating. (See p. 25.)	Selling price of 2,000 pounds at the point of selection.	Sample number.
	Soluble in water.	Reverted.	Insoluble.	Total.		Available.		Present as muriate.	Present as sulphate.	Total.		Found.	Guaranteed.				
				Found.	Guaranteed.	Found.	Guaranteed.			Found.	Guaranteed.						
10.07	5.21	3.88	2.70	11.77	9.00	9.07	8.00	3.65	.....	3.65	3.00	*1.54	1.63	25.59	26.00	293
															21.50	578	
10.25	7.40	2.34	1.93	11.67	.....	9.74	8.50	3.33	5.95	*9.28	10.00	1.92	1.85	34.36	30.00	67
															28.50	577	
7.60	8.33	3.28	2.18	13.79	12.00	11.61	10.00	2.09	.....	2.09	1.50	*2.07	2.35	23.80	31.00	204
7.10	7.44	2.43	3.33	13.25	12.00	*9.87	10.00	1.99	.....	1.99	1.50	*2.01	2.35	27.08	23.00	485
															26.00	496	
9.11	6.25	2.25	2.35	10.85	8.00	8.50	7.00	1.60	.61	2.21	2.00	*1.20	1.82	22.23	24.00	583	
10.62	6.50	2.09	1.99	10.58	8.75	8.59	7.75	6.80	.48	7.28	7.00	*3.56	3.70	36.13	.....	490
5.62	3.10	3.40	1.70	8.20	.....	*6.50	7.00	1.07	4.90	5.97	5.00	4.14	4.12	35.00	32.00	465
															35.75	377	
7.45	3.06	5.19	4.72	12.97	.....	*8.25	10.00	3.25	.....	3.25	2.50	2.74	2.47	29.43	32.00	466
															35.75	378	
7.05	2.51	4.73	4.13	11.37	.....	*7.24	8.00	6.45	.....	6.45	6.00	*2.44	2.47	30.20	36.00	553
															36.00	256	
9.65	2.27	2.30	2.67	7.24	.....	4.57	4.00	.80	3.80	9.10	8.00	3.63	3.23	35.23	36.75	379
															36.00	484	
5.80	4.13	3.34	2.54	10.01	.....	*7.47	8.00	.67	7.20	7.87	6.00	3.71	3.71	37.23	41.00	252
															39.00	553	
4.23	.35	2.47	2.96	5.78	.....	*2.82	4.50	.53	11.19	11.72	10.50	*6.17	6.18	45.78	45.00	557
5.67	3.38	3.71	2.27	9.36	.....	7.09	6.00	.67	6.51	7.13	6.00	5.05	4.94	40.87	42.50	253
															40.00	554	
9.57	6.80	1.65	3.32	11.77	9.00	8.45	8.00	2.32	.....	*2.92	3.00	1.73	1.65	25.41	25.00	646
9.35	5.93	2.10	.93	*8.96	9.00	8.03	8.00	2.91	.....	2.91	2.00	1.01	.83	20.32	22.00	308
8.02	5.36	1.70	.83	*7.89	8.50	7.06	7.00	5.93	.....	5.93	5.00	.96	.83	22.72	24.00	256
7.25	5.08	2.32	1.53	8.93	8.50	7.40	7.00	1.47	.....	1.47	1.00	.53	.41	17.23	13.50	235

*Constituent falls below guarantee.

COMPLETE FERTI

Sample number.	Manufacturer and Brand.	From Whom Sample Was Taken.
	MILSOM RENDERING & FERTILIZER CO., EAST BUFFALO, N. Y.	
588	B. B. Guano,	W. H. Hoffman, New Tripoli,
588	Buffalo Fertilizer,	Win. F. Snyder, Stony Run,
487	Corn Fertilizer,	Tucker & Squires, Springboro,
255	Penna. Corn & Grain Grower,	Lord & Drake, Cambridge Springs,
608	{ †Potato, Hop & Tobacco Phosphate,	{ W. H. Diehl, Northumberland,
240			{ Walter B. Denny, Meadville, .....
626	{ Potato, Hop & Tobacco Phosphate,	{ J. H. Eddinger, Luthersburg,
504			{ I. G. Washburn, Montandon, .....
342	{ †Vegetable Bone Fertilizer,	{ Walter B. Denny, Meadville,
605			{ I. G. Washburn, Montandon, .....
357	{	{ Lord & Drake Cambridge Springs,
419			{ T. H. Schott, Danville, .....
341	{ †Wheat, Oats & Barley Phosphate,	{ Walter B. Denny, Meadville,
597			{ Wm. F. Snyder, Stony Run, .....
602	{	{ I. G. Washburn, Montandon,
624			{ J. H. Eddinger, Luthersburg, .....
	MORO PHILLIPS CHEM. CO., PHILADELPHIA, PA.	
500	Fish Guano,	J. J. Mitman, Bethlehem,
190	No. 1 Potato & Truck Manure,	M. M. Gillis, Penn's Dale,
	WM. C. NEWPORT CO., WILLOW GROVE, PA.	
69	10 per cent. Potash Phosphate,	H. C. Worstall, Newtown,
	NIAGARA FERTILIZER WORKS, BUFFALO, N. Y.	
164	{ †Niagara Potato, Tobacco & Hop Fertilizer, ...	{ J. A. McKee, Clintonville,
624			{ A. W. Smith, Falls Creek, .....
	OHIO FARMER'S FERTILIZER CO., COLUMBUS, OHIO.	
167	{ †General Crop Fish Guano,	{ Rob't Ivell, Clintonville,
526			{ B. F. McClure & Bro., Burgettstown, ....

For explanation of these tables see p. 27. †Composite sample.

LIZERS—Continued.

Moisture in 100 pounds.	Phosphoric Acid in 100 Pounds.								Potash in 100 Pounds. (Water Soluble.)				Nitrogen in 100 pounds.		Computed commercial value of 2,000 pounds at Department rating. (See p. 25.)	Selling price of 2,000 pounds at the point of selection.	Sample number.
	Soluble in water.	Reverted.	Insoluble.	Total.		Available.		Present as muriate.	Present as sulphate.	Total.		Found.	Guaranteed.				
				Found.	Guaranteed.	Found.	Guaranteed.			Found.	Guaranteed.						
8.32	1.93	2.51	1.98	6.42	6.00	*4.44	5.00	1.13	.....	1.13	1.00	1.93	1.85	18.81	19.00	588
7.70	4.51	2.44	2.90	9.85	9.00	*6.95	8.00	1.07	.48	*1.55	4.00	1.79	.82	22.21	24.00	598	
12.09	4.45	3.25	3.19	10.89	10.00	*7.70	9.00	2.01	.....	2.01	2.00	*2.22	2.50	25.02	27.00	437
9.86	4.38	3.71	1.25	9.34	9.00	8.09	8.00	1.15	.....	1.15	1.00	.84	.82	18.62	23.00	355
8.75	5.52	2.54	1.75	9.81	9.00	8.06	3.00	3.48	.....	3.48	3.00	*1.81	2.06	24.87	28.50	608
															28.00	343	
															32.00	626	
10.16	4.19	2.57	2.27	9.03	9.00	*6.76	8.00	3.67	.....	3.67	3.00	*1.92	2.06	24.12	28.00	604
10.56	5.88	1.70	2.04	9.62	9.60	*7.58	8.00	5.00	.....	*5.00	7.00	3.81	3.23	33.48	34.00	342
															34.00	605	
															24.00	357	
															25.00	419	
															28.00	341	
8.53	4.89	2.83	2.12	9.84	9.00	*7.72	8.00	1.80	.....	*1.80	2.00	1.09	.82	20.30	23.00	597
															24.00	602	
															25.00	625	
8.62	3.93	3.22	1.71	8.86	6.00	7.15	5.00	1.62	.....	1.52	1.60	*1.68	1.85	21.27	25.00	500
6.74	6.00	1.92	1.56	*9.48	10.00	*7.92	8.00	6.49	.....	6.49	6.00	*1.80	2.06	27.79	30.00	199
7.72	2.95	2.33	3.80	9.08	8.00	*5.28	6.00	3.71	.....	*8.71	10.00	1.65	1.65	27.33	29.00	69
9.37	4.77	3.37	2.74	10.88	9.00	8.14	8.00	3.59	.....	3.59	3.00	2.06	2.06	26.41	28.00	164
															24.40	624	
9.10	1.94	6.13	2.94	11.01	9.00	8.07	8.00	1.06	.....	1.06	1.00	*.78	.82	18.79	23.00	167
															24.00	526	

*Constituent falls below guarantee.

COMPLETE FERTI

Sample number	Manufacturer and Brand.	From Whom Sample Was Taken.
171	Improved Wheat Maker,	Eugene Burnitt, Utica,
173	Potato and Truck Fertilizer,	A. J. Andrews, Cochranton,
659	Tobacco Grower, Potato & Truck Fertilizer,	W. M. Hawthorne, Sturgis,
	OSCEOLA FERTILIZER CO., OSCEOLA MILLS, PA.	
631	{ Ideal Mixture,	J. R. Staver, Clearfield,
632		R. R. Fleming, Houtzdale,
	PACIFIC GUANO CO., NEW YORK.	
59	{ A No. 1 Phosphate,	J. G. Hackman, Lansdale,
495		F. P. Semmel, Unionville,
60	{ Nobsque Guano,	J. G. Hackman, Lansdale,
444		C. F. Meyers, McKane,
58	{ Potato Phosphate,	J. G. Hackman, Lansdale,
445		C. F. Meyers, McKane,
	PACKER'S UNION FERTILIZER CO., NEW YORK.	
36	{ American Wheat and Rye Grower,	J. W. Glatfelder, Rossville,
541		Wm. S. Weller, Husband,
285	Animal Corn Fertilizer,	N. D. Bowman, Stanton's Mills,
249	{ Animal Corn Fertilizer,	M. O. Reagle, Mt. Bethel,
533		Maust & Reitz, Confluence,
405	H. G. Animal Corn Fertilizer,	R. C. Heffley, Berlin,
320	{ H. G. Potato Manure,	H. J. Krumenacker, Carrolltown,
540		Wm. S. Weller, Husband,
370	H. G. Universal Fertilizer,	Levi H. Miller, Reeders,
247	{ Potato Manure,	M. O. Reagle, Mt. Bethel,
71		H. C. Worstall, Newtown,
531	{	Maust & Reitz, Confluence,
70		H. C. Worstall, Newtown,
254	{	Jno. L. Nisley, Middletown,
37		J. W. Glatfelder, Rossville,
321	{ Universal Fertilizer,	H. J. Krumenacker, Carrolltown,
532	{	Maust & Reitz, Confluence,
542		Wm. S. Weller, Husband,

For explanation of these tables see p. —. †Composite sample.

LIZERS—Continued.

Moisture in 100 pounds.	Phosphoric Acid in 100 Pounds.							Potash in 100 Pounds. (Water Soluble.)				Nitrogen in 100 pounds.		Computed commercial value of 2,000 pounds at Department rating. (See p. 25.)	Selling price of 2,000 pounds at the point of selection.	Sample number.
	Soluble in water.	Reverted.	Insoluble.	Total.		Available.		Present as muriate.	Present as sulphate.	Total.		Found.	Guaranteed.			
				Found.	Guaranteed.	Found.	Guaranteed.			Found.	Guaranteed.					
9.57	1.93	5.22	1.52	*8.67	9.00	*7.15	8.00	2.77	.....	2.77	2.50	.49	.41	17.74	21.00	171
8.79	5.90	3.38	1.23	10.51	9.00	9.28	8.00	.....	3.31	*3.31	4.00	*1.84	2.47	26.58	28.50	173
5.00	2.01	4.63	2.76	9.40	9.00	*6.64	8.00	3.07	.....	*3.07	4.00	*1.63	2.47	22.40	29.00	659
6.20	.36	2.59	3.89	6.84	4.00	*2.95	3.00	2.80	.....	*2.80	3.00	*1.55	1.70	18.12	26.00	631
															25.00	632
13.15	4.66	3.93	2.11	10.70	8.00	8.59	7.00	2.05	.....	2.05	1.00	1.16	.83	21.63	23.00	59
															24.00	495
9.68	5.08	3.59	1.05	9.72	9.00	8.67	8.00	2.02	.....	2.02	2.00	1.13	1.02	21.18	22.50	60
															22.00	444
15.21	4.47	3.08	1.99	9.54	7.00	7.55	6.00	4.57	.....	*4.57	5.00	1.40	1.23	23.90	23.00	58
															25.00	445
7.97	5.09	3.58	1.63	10.30	9.00	8.67	8.00	2.26	.....	2.26	2.00	.87	.82	20.64	18.00	36
															21.00	541
11.05	7.45	2.29	1.12	10.87	9.00	9.74	8.00	2.25	.....	2.25	2.00	*2.32	2.47	27.20	25.00	335
11.52	6.46	2.65	1.57	10.68	9.00	9.11	8.00	2.31	.....	2.31	2.00	*2.37	2.47	24.28	23.00	249
9.05	6.47	2.85	1.85	11.17	9.00	9.32	8.00	3.38	.....	3.38	2.00	*2.33	2.47	23.33	23.00	533
															27.00	405
8.18	5.92	2.17	1.37	9.46	9.00	8.09	8.00	6.57	.....	6.57	6.00	*1.83	2.05	23.09	27.00	330
11.65	2.98	7.01	.92	10.91	9.00	9.99	8.00	3.33	1.85	5.18	4.00	.98	.82	25.35	29.00	540
															26.00	370
10.23	5.51	3.38	1.76	10.63	9.00	8.87	8.00	5.52	.....	*5.52	6.00	*1.92	2.05	23.21	30.00	247
															30.00	71
11.02	5.61	2.98	1.40	9.94	9.00	8.54	8.00	4.14	.....	4.14	4.00	.88	.82	22.57	30.00	531
															25.00	70
															24.00	254
															23.00	87
															21.00	321
															25.00	532
															23.00	542

*Constituent falls below guarantee.

46-7-1900

COMPLETE FERTI

Sample number	Manufacturer and Brand.	From Whom Sample Was Taken.	
248	Wheat and Rye Grower, PATAPSCO GUANO CO., BALTIMORE, MD.	M. O. Reagle, Mt. Bethel,	
92	{ Coon Brand Guano, }	Jacob Fritz, New Bloomfield, }	
39		D. R. Heck, Lewisberry, }	
96		Joseph Burkholder, Hummelstown, }	
141		Jonathan Geesey, Dallastown,	
610		W. C. Rearick, Centre Hall,	
562	Coon Brand Guano,	Benj. H. Brown, Tunkhannock,	
93	Corn and Tomato Fertilizer,	Jacob Fritz, New Bloomfield,	
40	Grain and Grass Producer,	D. R. Heck, Lewisberry,	
142	Sea Gull Guano,	Jonathan Geesey, Dallastown,	
94	Tobacco & Potato Fertilizer,	Hershey & Rupley, Marysville,	
	PENNSYLVANIA AMMONIA & FERTILIZER CO., HARRISBURG, PA.		
268	Potato, Vegetable & Tobacco Fertilizer,	M. D. Ebersole, Middletown,	
267	Special Brand Fertilizer,	M. D. Ebersole, Middletown,	
	PITTSBURG PROVISION CO., PITTSBURG, PA.		
339	Keystone Fertilizer,	D. H. LeFevre, Hayfield,	
340	Pure Bone with Potash,	D. H. LeFevre, Hayfield,	
	R. H. POLLOCK, BALTIMORE, MD.		
635	Special Potato & Tobacco Fertilizer,	J. A. C. Rider, Tyrone,	
633	Superior Corn & Tomato Fertilizer,	J. A. C. Rider, Tyrone,	
	QUINNIPIAC CO., NEW YORK.		
282	{ †Climax Phosphate, }	Paxton Flour & Feed Co., Bowmansdale, }	
425		H. G. Supplee, Bloomsburg, }	
200		{ †Special Potato, }	M. Gillis, Penn's Dale, }
244			Edward J. Houck, Bangor, }
	RASIN-MONUMENTAL CO., BALTIMORE, MD.		
220	Monumental Potato Manure,	Wilson & Mendenhall, Toughkenamon,	
276	Rasin's Dissolved Bone,	J. H. Warick, Mechanicsburg,	

For explanation of these tables see p. 27. †Composite sample.

LIZERS—Continued.

Moisture in 100 pounds.	Phosphoric Acid in 100 Pounds.								Potash in 100 Pounds. (Water Soluble.)				Nitrogen in 100 pounds.		Computed commercial value of 2,000 pounds at Department rating. (See p. 25.)	Selling price of 2,000 pounds at the point of selection.	Sample number.
	Soluble in water.	Reverted.	Insoluble.	Total.		Available.		Present as muriate.	Present as sulphate.	Total.		Found.	Guaranteed.				
				Found.	Guaranteed.	Found.	Guaranteed.			Found.	Guaranteed.						
11.96	5.24	2.83	2.15	10.22	.....	8.07	.....	2.13	.....	2.13	.....	.84	.....	20.12	21 00	248
10.34	6.62	3.02	1.17	10.81	10.00	9.64	9.00	3.08	.....	3.08	3.00	.92	.82	22.69	19.00	92
															19.00	39	
															18.50	95	
															22.00	141	
10.05	7.22	2.36	1.07	10.65	10.00	9.58	9.00	3.12	.....	3.12	3.00	.90	.82	22.66	25.00	552
															25.00	552	
															25.00	552	
															25.00	552	
11.53	7.09	3.20	1.34	11.03	11.00	10.29	9.00	2.29	.....	2.29	2.00	*1.22	1.23	23.84	22.00	98
10.40	6.66	3.69	2.03	12.27	10.00	10.24	8.00	2.68	.....	*2.68	4.00	1.25	.82	24.64	22.00	40
11.19	2.65	6.15	1.63	10.43	9.00	8.80	8.00	1.24	.....	1.24	1.00	*.80	.82	19.35	20.00	142
9.60	6.49	2.52	1.16	10.17	9.00	9.01	8.00	3.72	.....	*3.72	4.00	1.69	1.65	25.56	25.00	94
7.89	4.19	4.97	1.66	10.72	10.50	9.16	9.00	11.24	.....	11.24	9.00	*1.43	1.65	32.41	32.00	265
7.75	4.14	4.68	2.25	11.07	9.50	8.82	8.00	2.44	.....	2.44	2.00	.92	.82	21.33	18.50	257
4.20	1.69	4.76	6.45	12.90	11.00	*6.45	9.00	.....	.93	*.93	1.50	2.04	1.60	25.68	21.00	339
6.96	2.37	4.10	8.38	14.83	14.00	*6.47	12.00	.63	1.36	*2.79	3.00	2.84	2.50	29.55	27.00	340	
7.52	7.06	2.69	2.46	12.11	10.00	9.05	9.00	4.25	.....	4.25	4.00	*1.75	2.06	27.69	30.00	635
8.62	4.50	3.97	1.62	10.09	10.00	*8.47	9.00	2.29	.....	2.29	2.00	.98	.82	20.96	23 00	633
10.76	5.52	3.72	2.18	11.42	9.00	9.24	8.00	2.47	.....	2.47	2.00	1.32	1.02	23.38	24.00	283
8.95	2.38	4.20	2.41	8.99	8.00	6.58	6.00	5.12	.....	5.12	5.00	*1.13	1.23	22.46	25.00	425
															25.00	200	
															23.00	244	
7.87	1.83	6.73	3.36	11.82	7.00	8.56	6.00	4.89	.....	4.89	4.00	1.52	.82	26.00	22.00	220
7.27	5.62	5.28	3.61	14.51	11.50	10.90	10.00	.79	.....	.79	.....	*1.47	1.64	24.79	21.75	276

*Constituent falls below guarantee.

COMPLETE FERTI

Sample number.	Manufacturer and Brand.	From Whom Sample Was Taken.
	E. RAUH & SONS FERTILIZER CO., INDIANAPOLIS, IND.	
353	Acidulated Bone,	Geo. Boda, Cambridge Springs,
344	Dissolved Bone and Potash,	E. R. Humeston, Guy's Mills,
350	} †Special Corn & Potato, {	Geo. Baricman, Meadville,
354		Geo. Boda, Cambridge Springs,
	READ FERTILIZER CO., NEW YORK CITY.	
159	Farmer's Friend Super Phosphate,	Fields Bros., Wellsboro,
264	Leader Blood and Bone Phosphate,	Jerome S. Williams, Stroudsburg,
158	Leader Guano,	Fields Bros., Wellsboro,
362	Practical Potato Special Fertilizer,	Jerome S. Williams, Stroudsburg,
246	} †Standard Super Phosphate, {	Lingo Bros., Guy's Mills,
157		Fields Bros., Wellsboro,
263		Jerome S. Williams, Stroudsburg,
154	Vegetable & Vine Fertilizer,	Fields Bros., Wellsboro,
	READING CHEM. & FERTILIZER CO., READING, PA.	
61	Potato and Vegetable Fertilizer,	H. C. Moyer, Perkasee,
	JOHN S. REESE & CO., BALTIMORE, MD.	
18	Fruit & Vine Fertilizer,	Ball & Rhodes, Media,
24	Pilgrim Fertilizer,	Matthew Elliott & Co., Media,
19	Potato Manure,	Ball & Rhodes, Media,
20	Standard Fertilizer,	Ball & Rhodes, Media,
559	Potato & Truck Special,	G. S. Vincent, So. Towanda,
	ENOS RICHMOND, ELMER, N. J.	
361	Special Corn, Truck & Potato Phosphate,	Jacob Chamberlain, Portland,
246	Special Potato Phosphate,	Jacob Chamberlain, Portland,
	RIVERSIDE ACID WORKS, WARREN, PA.	
175	Harvest Moon,	F. S. Vernier, Pettis,
174	Rich Acre,	F. S. Vernier, Pettis,

For explanation of these tables see p. 37. †Composite sample.

LIZERS—Continued.

Moisture in 100 pounds.	Phosphoric Acid in 100 Pounds.								Potash in 100 Pounds. (Water Soluble.)				Nitrogen in 100 pounds.		Computed commercial value of 2,000 pounds at Department rating. (See p. 25.)	Selling price of 2,000 pounds at the point of selection.	Sample number
	Soluble in water.	Reverted.	Insoluble.	Total.		Available.		Present as muriate.	Present as sulphate.	Total.		Found.	Guaranteed.				
				Found.	Guaranteed.	Found.	Guaranteed.			Found.	Guaranteed.						
8.40	3.40	4.08	2.90	*10.38	11.00	*7.48	8.00	.50	.....	.50	.....	1.17	.32	19.10	19.00	353
9.24	4.49	4.26	4.84	13.59	11.00	8.75	7.00	1.93	.....	1.93	1.50	*1.26	1.65	23.37	24.00	344
7.46	4.44	3.97	5.99	14.40	9.00	8.41	6.00	2.53	1.49	4.02	2.00	*1.92	2.88	23.32	27.50 30.00	250 354	
10.25	4.87	1.65	1.18	*7.68	8.50	*6.52	8.00	9.63	.....	9.63	3.00	3.44	2.10	35.36	35.00	159
11.26	4.21	3.42	2.04	9.67	7.50	7.63	7.00	1.56	.....	1.56	1.00	.93	.83	19.22	20.00	364
12.32	4.94	2.59	1.83	8.91	7.50	7.53	7.00	1.33	.....	1.33	1.00	1.10	.83	19.27	22.00	158
7.02	1.53	3.12	2.65	7.30	.....	4.65	.....	8.00	.....	8.00	.....	.85	.....	22.21	28.00	362
9.62	5.23	3.11	1.20	9.59	8.50	8.39	8.00	4.09	.....	4.09	4.00	.90	.83	22.22	22.00 25.00	157 363
9.77	6.23	2.06	1.55	9.84	8.50	8.29	8.00	6.63	.....	6.63	6.00	*2.04	2.10	22.23	30.00	156
6.10	2.25	2.55	1.92	*6.72	9.00	*4.80	7.00	8.01	.....	8.01	5.50	*1.61	2.06	24.38	.....	61
7.77	5.89	3.93	.36	10.18	.....	9.82	.....	5.07	.86	6.03	.....	1.01	.....	25.99	26.00	18
8.50	1.44	7.24	1.99	10.67	10.00	8.68	8.00	2.70	.....	*2.70	4.00	.98	.82	21.39	25.00	24
9.70	7.73	3.07	.69	11.49	11.00	10.80	9.00	6.83	.....	*6.89	7.00	1.17	.82	28.66	26.00	19
10.70	7.32	2.70	.37	*10.29	11.00	10.02	9.00	2.47	.....	2.47	2.00	*2.43	2.47	27.87	26.00	20
10.40	5.55	2.38	3.01	10.94	10.00	*7.93	8.00	7.08	.....	7.08	7.00	*2.96	3.29	23.32	24.00	559
9.10	3.66	3.25	5.05	11.96	.....	6.91	.....	5.79	.....	5.70	.....	1.07	.....	24.45	23.00	361
11.32	6.31	2.27	1.78	10.31	.....	8.58	.....	11.60	.....	11.60	.....	1.67	.....	33.21	28.00	346
10.05	6.81	2.43	.23	9.51	7.75	9.29	7.00	.....	.86	*.86	1.10	.95	.80	19.32	23.00	173
12.00	9.39	1.23	.11	11.13	8.75	11.02	8.00	.....	1.70	1.70	1.60	1.86	1.60	26.49	26.00	174

*Constituent falls below guarantee.

COMPLETE FERTI

Sample number.	Manufacturer and Brand.	From Whom Sample Was Taken.
	ISAAC ROBINSON, BALTIMORE, MD.	
122	Special Potato & Tomato Phosphate,	A. J. Galbraith, Woodbine,
123	Standard Dissolved Bone Phosphate,	A. J. Galbraith, Woodbine,
	SCHAAL-SHELDON FERTILIZER CO., ERIE, PA.	
176	Corn & Potato,	Sheldon Brooks, Geneva,
178	Farmer's Favorite,	Sheldon Brooks, Geneva,
611	Farmer's Favorite for Wheat & Corn,	W. Sherbine, Willmore,
334	{ Sheldon's Empire,	W. Sherbine, Willmore,
347		Louis Doubet, Frenchtown,
618	{ Sheldon's Guano,	W. Sherbine, Willmore,
661		J. A. Einhipple, Albion,
248	Standard Phosphate,	Louis Doubet, Frenchtown,
	SCIENTIFIC FERTILIZER CO., PITTSBURG, PA.	
161	{ Corn & Grain,	James Shaffer, Cyrus,
233		Davidsville,
	SCOTT FERTILIZER CO., ELKTON, MD.	
619	Elk Head Super Phosphate,	Miles Wrigley, Mahaffey,
620	Potato Fertilizer No. 2,	Miles Wrigley, Mahaffey,
	SHARPLESS & CARPENTER, PHILADELPHIA, PA.	
229	Evans's Potato Manure,	Geo. K. Linderman, White Bear,
237	{ Gilt Edge Potato & Tobacco Manure,	Geo. K. Linderman, White Bear,
23		Matthew Elliott & Co., Media,
594	{ No. 2 for Grain & Grass,	Louis F. Mosier, Mosierville,
284		B. F. Cocklin, Grantham Sta.,
224	{ Potato, Corn & Truck Guano,	Deweese & Bracken, Paoli,
193		G. M. Tule, Montoursville,
226	{ Royal Spring Mixture,	Geo. K. Linderman, White Bear,
228		Geo. K. Linderman, White Bear,
360	{	Jno. F. Stier, Johnsonville,

For explanation of these tables see p. 27. †Composite sample.

LIZERS—Continued.

Moisture in 100 pounds.	Phosphoric Acid in 100 Pounds.								Potash in 100 Pounds. (Water Soluble.)				Nitrogen in 100 pounds.		Computed commercial value of 2,000 pounds at Department rating. (See p. 25.)	Selling price of 2,000 pounds at the point of selection.	Sample number.*
	Soluble in water.	Reverted.	Insoluble.	Total.		Available.		Present as muriate.	Present as sulphate.	Total.		Found.	Guaranteed.				
				Found.	Guaranteed.	Found.	Guaranteed.			Found.	Guaranteed.						
9.01	6.10	2.21	1.33	9.74	10.00	8.41	7.50	2.65	.....	2.65	2.25	1.08	1.65	23.32	22.00	122
10.44	8.15	2.53	1.07	11.74	11.50	10.67	10.00	2.43	.....	2.43	2.00	.96	.82	23.48	19.00	123
12.02	5.11	2.95	1.77	9.83	9.00	8.06	8.00	4.31	.....	4.31	4.00	*1.74	2.45	25.48	29.00	176
10.55	4.86	3.29	2.10	10.25	9.00	8.15	8.00	.....	3.33	3.33	2.00	*1.05	1.15	22.72	.....	178
9.43	4.29	3.32	2.33	10.09	9.00	*7.71	8.00	1.77	.....	*1.77	2.00	*1.14	1.15	20.47	22.90	611
8.60	3.62	4.00	1.63	9.25	.....	7.62	.....	1.71	.....	1.71	.....	.99	.....	19.29	23.00	334
9.29	4.65	2.86	2.24	9.75	8.00	7.51	7.00	1.51	.....	1.51	1.00	1.74	1.65	22.20	23.00	613
10.57	4.25	3.76	2.15	10.16	9.00	8.01	8.00	3.14	.....	3.14	2.00	*1.28	1.65	22.64	21.00	651
7.51	3.98	2.80	2.65	9.43	8.50	*6.78	7.00	3.24	.....	3.24	2.00	1.56	1.50	22.58	18.00	161
7.32	3.95	3.31	1.53	11.79	.....	10.26	9.00	.....	1.50	1.50	1.00	*.77	.82	21.64	18.00	323
8.75	5.32	2.86	2.42	11.21	.....	8.79	6.00	5.53	.....	*5.53	10.00	2.16	1.65	29.44	23.00	619
9.28	4.22	3.58	1.53	8.99	7.00	7.46	6.00	3.90	.....	*8.90	10.00	*2.74	3.29	32.08	32.00	227
10.02	6.85	2.49	1.95	11.29	10.00	9.34	8.00	10.15	.....	10.15	10.00	1.70	1.65	32.94	29.00	22
9.52	7.92	3.97	.64	12.53	8.00	11.89	7.00	1.12	.....	1.12	1.00	*.53	.82	21.70	30.00	594
6.71	3.75	3.04	1.59	8.38	7.00	6.79	6.00	5.19	.....	5.19	5.00	1.40	1.22	22.42	24.00	224
10.25	4.85	4.12	1.65	10.63	10.00	8.98	8.00	2.12	.....	2.12	2.00	.87	.82	20.91	22.50	226
															20.00	229	
															24.00	230	

*Constituent falls below guarantee.

COMPLETE FERTI

Sample number	Manufacturer and Brand.		From Whom Sample Was Taken.	
	SHENANDOAH FERTILIZER CO., SHENANDOAH, PA.			
259	{	†Gold Eagle Brand,	{	J. A. Romberger, Elizabethtown,
78				Wm. Lindsay, Reward,
305	{	†N. & S. Complete Fertilizer,	{	Steininger Bros., Middleburg,
79				Wm. Lindsay, Reward,
304	{	Ringtown Clover,	{	Steininger Bros., Middleburg,
306				Steininger Bros., Middleburg,
272	{	†Shenandoah Brand,	{	A. Cameron Bobb, Paxinos,
585				Mahlon C. Dietrich, Kempton,
587		Standard Potash Fertilizer,		Mahlon C. Dietrich, Kempton,
	M. L. SHOEMAKER & CO., PHILADELPHIA, PA.			
57		‡‡ Phosphate,		Kline Van Winkle, Glenside,
	CHAS. A. SICKLER & BRO., WILKES-BARRE, PA.			
373		Empire Phosphate,		Geo. Hoffner, Effort,
555		Special Manure for Potatoes & Vegetables,		Howard F. Brunges, Tunkhannock,
	H. H. SMYSER, YORK, PA.			
290		Chicago Bone & Potash,		H. H. Smyser, York,
291		Chicago Bone & Tankage,		H. H. Smyser, York,
	SOUTHERN FERTILIZING CO., YORK, PA.			
206	{	†Ammoniated Dissolved Bone,	{	Passmore & Gillisple, Nottingham,
294				Wagner & Earnst, York,
129	{		{	R. B. Hyson, Bridgeton,
501				Levin A. Lerch, Bethlehem,
615	{		{	Fletcher C. George, Lilly,
129				R. B. Hyson, Bridgeton,
150	{		{	J. W. Getts, Lock Haven,
47				Geo. Nell, Bermudian,
400	{	†Farmer's Choice Brand,	{	Simon Foust, Beachdale,
502				Levin A. Lerch, Bethlehem,
592				Jesse Weaver, Mosier,

For explanation of these tables see p. 27. †Composite sample.

LIZERS—Continued.

Moisture in 100 pounds.	Phosphoric Acid in 100 Pounds.								Potash in 100 Pounds. (Water Soluble.)				Nitrogen in 100 pounds.		Computed commercial value of 2,000 pounds at Department rating. (See p. 26.)	Selling price of 2,000 pounds at the point of selection.	Sample number.
	Soluble in water.	Reverted.	Insoluble.	Total.		Available.		Present as muriate.	Present as sulphate.	Total.		Found.	Guaranteed.				
				Found.	Guaranteed.	Found.	Guaranteed.			Found.	Guaranteed.						
9.35	3.74	3.82	2.19	9.75	8.00	7.56	7.00	1.12	.....	*1.12	1.85	*.76	.82	17.98	16.00	259
															18.00	73	
															19.00	305	
8.00	2.75	2.78	2.03	7.56	7.00	*5.53	6.00	.79	.....	*.70	1.00	.83	.41	15.57	17.00	79
															18.00	304	
9.40	3.38	4.07	2.65	10.70	.....	8.05	8.00	1.43	.....	*1.43	2.60	*1.04	1.65	20.24	23.00	306
8.49	5.14	3.11	1.45	9.70	8.00	8.25	7.00	3.79	.....	*3.79	6.00	*.92	1.65	21.85	33.00	272
															30.00	585	
5.27	3.60	2.49	1.74	7.83	.....	*6.09	8.00	2.36	.....	*2.36	4.00	*.93	1.23	18.20	25.00	587
6.11	1.77	4.49	7.89	14.15	8.00	6.26	6.00	2.05	.....	2.05	1.00	1.37	.83	22.27	25.00	57
9.26	2.26	2.94	2.02	*7.22	12.00	*5.20	17.00	3.05	.....	3.08	2.00	*1.54	1.85	20.19	27.00	373
6.40	1.97	2.52	3.48	*7.97	9.00	*4.49	8.00	9.31	.....	9.31	6.50	*1.70	3.29	26.94	38.00	555
6.30	3.79	4.52	2.00	10.31	.....	8.31	8.00	4.21	.....	4.21	4.00	*.73	1.00	21.85	23.00	290
8.53	1.20	7.96	3.42	12.58	.....	9.16	8.00	.91	.....	*.91	1.00	*.48	1.00	12.87	20.00	291
															24.00	308	
															26.00	294	
9.92	6.12	3.72	1.68	11.52	11.20	*9.84	10.00	2.78	.....	2.78	2.50	*1.48	1.70	24.97	24.00	129
															25.00	501	
															27.00	615	
															20.00	128	
															30.00	150	
9.10	4.85	3.53	1.42	*9.80	10.00	*8.38	9.00	2.29	.....	2.29	2.00	.86	.82	20.25	21.00	47
															22.00	400	
															21.00	502	
															23.00	592	

*Constituent falls below guarantee.

COMPLETE FERTI

Sample number	Manufacturer and Brand.	From Whom Sample Was Taken
295	{†General Crop Grower,}	Wagner & Earnst, York,}
399		Simon Foust, Beachdale,}
402		Simon Foust, Beachdale,}
614		Fletcher C. George, Lilly,}
401	{†Queen of the Harvest,}	Simon Foust, Berlin,}
151		J. W. Getz, Jr., Lock Haven,}
576		Levin A. Lerch, Bethlehem,}
589		Jesse Weaver, Mosierville,}
	STRAYER BROS., YORK, PA.	
275	Wheat, Corn & Grass Grower,	W. K. Strayer, York,
	SUSQUEHANNA FERTILIZER CO., BALTIMORE, MD.	
332	{†Bone Phosphate,}	C. Neas, Geistown,}
560		B. A. Cramer, Monroeton,}
478	{†Potato Phosphate,}	Geo. B. Passmore & Sons, Oxford,}
333		C. Neas, Geistown,}
563	{Potato Phosphate,}	B. A. Cramer, Monroeton,}
281		H. S. Heisey, Williams Mills,}
562	Susquehanna Crop Grower,	B. A. Cramer, Monroeton,
471	{†XXV Phosphate,}	Jos. Brown, Jennerville,}
279		Geo. Bridges, Carlisle,}
561		B. A. Cramer, Monroeton,}
600		Alex. Billmeyer, Washingtonville,}
	SWIFT & CO., CHICAGO, ILL.	
508	Pure Ammonia Bone & Potash,	C. H. Schmucker, Fridens,
	JAMES THOMAS, WILLIAMSPORT, PA.	
76	H. G. Potato Manure,	L. M. Watts, Bellville,
319	{H. G. Potato & Tobacco Manure,}	Barker Bros., Ebensburg,}
616		E. J. Hughes, Lilly,}
617	H. G. Bone Super Phosphate,	E. J. Hughes, Lilly,

For explanation of these tables see p. 27. †Composite sample.

LIZERS—Continued.

Moisture in 100 pounds.	Phosphoric Acid in 100 Pounds.							Potash in 100 Pounds. (Water Soluble.)				Nitrogen in 100 pounds.		Computed commercial value of 2,000 pounds at Department rating. (See p. 25.)	Selling price of 2,000 pounds at the point of selection.	Sample number.
	Soluble in water.	Reverted.	Insoluble.	Total.		Available.		Present as muriate.	Present as sulphate.	Total.		Found.	Guaranteed.			
				Found.	Guaranteed.	Found.	Guaranteed.			Found.	Guaranteed.					
10.17	4.50	3.89	.90	9.29	9.00	8.39	8.00	3.27	.....	3.27	2.00	.62	.41	19.99	20.00	295
															20.00	399
10.31	5.42	4.13	1.67	*11.22	17.50	*9.55	10.00	2.59	.....	2.59	2.00	*1.21	1.24	23.28	23.00	402
															25.00	614
															24.00	401
2.52	5.66	2.66	1.74	10.26	9.50	8.52	8.00	4.13	.....	4.13	4.00	*1.16	1.24	23.62	33.00	151
															23.00	576
															27.00	593
7.48	4.66	3.80	1.94	9.70	.....	*8.46	9.00	2.37	.....	2.37	2.00	.84	.82	20.25	21.00	275
9.06	4.19	4.20	4.22	12.61	10.00	8.39	8.00	2.36	...	2.36	2.00	1.63	1.50	24.54	22.00	332
															23.00	560
															25.00	478
10.09	6.41	2.63	2.51	11.55	10.00	9.04	8.00	5.48	.....	5.48	5.00	1.68	1.50	23.09	23.00	333
															30.00	563
10.42	6.63	2.40	2.21	11.24	10.00	9.03	8.00	5.66	.....	5.66	5.00	1.72	1.50	23.11	27.00	281
6.24	2.51	5.09	5.48	13.08	9.00	7.60	7.00	1.42	.....	1.42	1.00	.95	.82	20.52	20.00	562
8.75	5.35	4.18	2.77	12.30	10.00	9.53	8.00	1.40	.....	1.40	1.00	1.05	.82	22.02	15.00	471
															24.00	279
															23.00	561
															13.00	600
6.55	3.67	4.96	8.04	16.67	16.00	8.63	.....	.53	1.78	*2.31	3.00	*1.82	4.75	27.25	23.00	508
9.45	4.85	3.32	1.66	*9.83	12.00	*8.17	9.00	5.64	.....	*5.64	6.00	*2.03	2.06	23.03	35.00	75
8.75	4.41	3.93	1.37	*9.71	12.00	*8.34	9.00	4.66	.....	*4.66	6.00	*1.70	2.06	25.66	34.00	319
9.98	6.51	2.97	2.21	*11.69	14.00	9.48	9.00	2.31	.....	2.31	2.50	*1.93	2.06	26.51	35.00	616
															22.00	617

*Constituent falls below guarantee.

COMPLETE FERTI

Sample number.	Manufacturer and Brand.		From Whom Sample Was Taken.	
31b	{	†Klondyke Amoniated Phosphate,	{	Barker Bros., Ebensburg,
429		Special Compound,		J. B. Smith, Washingtonville,
73		Standard Phosphate,		L. M. Watts, Bellville,
316	TYGERT-ALLEN FERTILIZER CO., PHILA.		Barker Bros., Ebensburg,	
571	Gold Edge Tobacco Manure,		J. Y. L. Ward, So. Towanda,	
56	{	†Potato Fertilizer,	{	Thos. Nicholson & Son, Jenkintown,
245		Star Bone Phosphate,		A. W. Sandt, Bangor,
202		Star Guano,		Frank Duffield, Langhorne,
569	{	Star Potato Grower,	{	J. Y. L. Ward, So. Towanda,
511		Wheat & Grass Special,		J. H. Thompson, Harmarville,
55				Thos. Nicholson & Son, Jenkintown,
216	F. K. WALT CO., WAYNESBURG JCT., PA.		E. B. Wood, Avondale,	
230	Potato and Tobacco Manure,		Jno. Buchman, Geigertown,	
579	XX Flesh Phosphate,		Jas. K. Bejler, Joanna,	
	M. E. WHEELER & CO., RUTLAND, VT.			
627	{	†Corn Fertilizer,	{	Jonathan Shafer, Luthersburg,
323				John S. Wetsell, Carrolltown,
648				A. McKinley, Franklin Corners,
367	{	†Potato manure,	{	Harry Edinger, Bartonville,
234				John S. Wetsell, Carrolltown,
660				Alva Smith, Little Cooley,
	WILLIAMS & CLARK FERTZ. CO., NEW YORK.			
133	Good Crop Potato Phosphate,		J. H. Gunkle, Bath,	
89	{	†Good Grower Potato Phosphate,	{	H. L. Tressler, Newport,
392				J. M. Fike, Bills,
	THE R. A. WOOLDRIDGE CO., BALTIMORE, MD.			
8	Champion Giant Phosphate,		Franklin G. Evans, Kelton,	
5	Triumph Pure Bone Phosphate,		Franklin G. Evans, Kelton,	

For explanation of these tables see p. 27. †Composite sample.

LIZERS—Continued.

Moisture in 100 pounds.	Phosphoric Acid in 100 Pounds.								Potash in 100 Pounds. (Water Soluble.)				Nitrogen in 100 pounds.		Computed commercial value of 2,000 pounds at Department rating. (See p. 25.)	Selling price of 2,000 pounds at the point of selection.	Sample number.
	Soluble in water.	Reverted.	Insoluble.	Total.		Available.		Present as muriate.	Present as sulphate.	Total.		Found.	Guaranteed.				
				Found.	Guaranteed.	Found.	Guaranteed.			Found.	Guaranteed.						
11.21	6.81	2.50	1.06	10.36	10.00	9.31	9.00	3.00	.....	3.00	3.00	.84	.82	21.99	28.50 20.00	215
11.20	7.51	2.48	1.20	11.19	11.00	9.99	9.00	3.06	.....	3.06	3.00	*.88	1.03	22.13		429
10.45	4.96	3.88	1.03	*9.86	10.00	8.83	8.00	3.17	.....	3.17	2.00	.63	.41	20.67	21.50	316
9.03	6.81	2.54	2.21	11.56	10.00	9.35	8.00	6.80	.....	6.80	6.00	2.12	2.06	31.12	30.00	571
11.16	5.23	3.30	2.03	10.56	10.00	8.53	8.00	2.16	.....	2.16	2.00	.92	.82	20.77	22.50 22.60	56
9.92	5.99	3.16	2.53	11.73	10.00	9.15	8.00	3.20	.68	3.88	3.00	2.10	2.05	28.17		245	
8.65	6.00	2.72	2.41	11.13	10.00	8.72	8.00	3.03	.....	3.03	3.00	*1.92	2.06	25.90	26.00	569
11.06	4.11	3.08	1.98	9.17	7.00	7.19	6.00	4.68	.....	*4.68	5.00	*1.09	1.23	22.50	26.00	511
4.40	1.88	3.24	.34	*5.54	9.00	*5.20	7.00	1.29	.....	1.29	1.00	1.44	.83	17.14	24.00	56
7.97	3.06	4.17	6.18	13.43	.....	7.25	.....	3.82	.....	3.82	.....	.99	.....	23.18	20.00	216
11.41	2.35	3.11	5.87	11.33	9.00	*5.46	8.00	2.40	.25	2.65	2.00	*.81	1.65	19.13	28.00	230	
9.49	5.96	3.05	1.99	11.02	9.00	9.03	8.00	2.23	.....	2.23	2.00	*1.51	1.64	22.78	25.00 24.00	579
9.72	5.27	3.25	2.02	10.54	9.00	8.52	8.00	3.27	.....	3.27	3.23	*1.93	2.05	26.81		627
11.93	3.85	3.18	1.83	8.86	7.00	7.03	6.00	4.73	.....	*4.73	5.00	*1.16	1.23	22.47	24.00	322
6.44	2.54	4.40	2.08	9.02	7.00	6.94	6.00	5.32	.....	5.32	5.00	1.26	1.23	23.28	25.00 25.00	648
8.96	6.06	3.39	1.83	11.28	10.50	9.45	9.00	3.11	.....	2.11	2.00	.91	.82	21.73		367
7.55	5.28	2.79	1.52	*9.59	10.00	8.07	8.00	4.25	.....	4.25	4.00	*1.18	1.23	22.30	26.00	324

*Constituent falls below guarantee.

COMPLETE FERTI

Sample number.		
	Manufacturer and Brand.	From Whom Sample Was Taken.
	YORK CHEMICAL WORKS, YORK, PA.	
113	Dempwolf's N. Y. Phosphate,	J. L. Brodbeck, Hanover,
	ZELL GUANO CO., BALTIMORE, MD.	
274	} †Economizer,	A. A. Ehrhart, Sprengel's School House, ..
525		
427	} †Hustler Phosphate,	H. G. Supplee, Bloomsburg,
114		
550	} Special Compound for Potatoes & Vegetables,	Peter Selp, Somerset,
545		
670	Special Compound for Potatoes,	W. M. Rice, Franklin,

For explanation of these tables see p. 27. †Composite sample.

LIZERS—Continued.

Moisture in 100 pounds.	Phosphoric Acid in 100 Pounds.								Potash in 100 Pounds. (Water Soluble.)				Nitrogen in 100 pounds.		Computed commercial value of 2,000 pounds at Department rating. (See p. 25.)	Selling price of 2,000 pounds at the point of selection.	Sample number.
	Soluble in water.	Reverted.	Insoluble.	Total.		Available.		Present as muriate.	Present as sulphate.	Total.		Found.	Guaranteed.				
				Found.	Guaranteed.	Found.	Guaranteed.			Found.	Guaranteed.						
9.87	1.29	5.22	2.53	10.04	10.00	*6.51	8.00	2.33	.....	2.33	2.00	.67	.41	18.10	17.50	113
7.44	7.20	2.64	1.99	11.83	.....	9.84	.....	2.18	.....	2.18	.....	.85	.....	22.28	19.50	274
															20.00	525	
															25.00	427	
8.95	8.14	2.64	1.80	12.58	11.00	10.78	9.00	3.16	.....	3.16	3.00	.93	.52	24.67	20.00	144
															23.50	550	
9.75	8.04	1.65	1.72	11.41	10.00	9.69	8.00	4.42	.....	4.42	4.00	*2.34	2.47	29.90	26.00	546
9.25	6.04	3.09	1.89	11.02	10.00	9.13	8.00	4.52	.....	4.52	4.00	*2.41	2.47	29.42	29.00	670

*Constituent falls below guarantee.

ROCK AND POTASH

Furnishing Phosphoric

Sample number.	Manufacturer and Brand.		From Whom Sample Was Taken.	
	ALLENTOWN MFG. CO., ALLENTOWN, PA.			
185	Phosphate and Potash,		Callahan & Weaver, Montoursville,	
	BALTIMORE PULVERIZING CO., BALTIMORE, MD.			
661	Anti Acid Phosphate,		A. J. Duchanois, Frenchtown,	
387	Penniman's Excelsior Fertilizer,		H. J. Hoffman, Jenners,	
307	} Special Spring Mixture, {		Steininger Bros., Middleburg, {	
115			Sheffer & Fry, Hanover, {	
283			H. J. Hoffman, Jenners, {	
	BAUGH & SONS COMPANY, PHILADELPHIA, PA.			
398	Soluble Alkaline Super Phosphate,		Peter Fink, Somerset,	
	A. H. BLAKER & CO., FOX CHASE, PA.			
473	Alkaline Bone,		Geo. W. Westcott, Oxford,	
	BOWKER FERTILIZER CO., BOSTON, MASS.			
179	} Empire State Bone and Potash, ..... {		....., Colton, {	
353			Osro Wykoff, Woodcock, {	
	BRADLEY FERTILIZER COMPANY, BOSTON, MASS.			
330	Alkaline Bone,		A. F. Stutzman, Johnstown,	
	S. B. BRODBECK, BRODBECK, PA.			
117	Alkaline Phosphate,		Sheffer & Fry, Hanover,	
	CHEMICAL CO. OF CANTON, BALTIMORE, MD.			
221	} Soluble Bone and Potash, {		Wilson & Mendenhall, Toughkenamon, .. {	
261			J. A. Romberger, Elizabethtown, {	
42			Jacob S. Bashore, Newberrytown, {	
302			N. B. Winey, Middleburg, {	
639			H. M. Gay, Tyrone, {	
642			H. L. Stults, Duncansville, {	
	CLARK'S COVE FERTILIZER CO., NEW YORK, N. Y.			
580	Triumph,		Solomon Livingood, Joanna,	

For explanation of these tables see p. 27. †Composite sample.

FERTILIZERS.

Acid and Potash.

Moisture in 100 pounds.	Phosphoric Acid in 100 Pounds.								Potash in 100 Pounds.				Computed commercial value at Department rating. (See p. 25.)	Selling price of 2,000 pounds at the point of selection.	Sample number.
	Soluble in water.	Reverted.	Insoluble.	Total.		Available.		Present as muriate.	Present as sulphate.	Total.					
				Found.	Guaranteed.	Found.	Guaranteed.			Found.	Guaranteed.				
9.76	3.33	10.67	2.53	16.63	13.00	14.05	13.00	4.29	.....	4.29	4.00	13.57	20.00	133
6.00	1.40	4.63	1.37	7.29	.....	6.02	.....	2.40	.....	2.40	.....	11.11	18.00	661
10.22	4.98	5.73	1.23	11.93	.....	10.70	.....	2.52	.....	2.52	.....	14.43	16.75	337
6.74	1.43	6.16	1.70	*9.29	10.00	*7.59	8.00	1.61	.....	1.61	1.25	11.33	15.00	307
													14.00	115	
													16.00	333	
12.85	7.21	3.98	.95	12.14	.....	11.19	10.00	2.26	.....	2.26	2.00	14.62	15.00	336
10.50	5.36	4.99	2.66	13.01	13.00	10.35	10.00	1.97	.....	*1.97	2.00	14.20	17.00	473
11.35	5.78	3.49	1.73	10.99	9.00	9.27	8.00	3.07	.....	3.07	3.00	14.40	19.00	179
													21.00	352	
12.14	5.91	5.03	1.40	12.34	11.00	10.94	10.00	2.21	.....	2.21	2.00	14.43	19.00	330
12.55	8.21	3.13	.82	12.16	.....	11.34	.....	2.32	.....	2.32	.....	14.84	15.00	117
11.77	6.59	4.53	.93	*11.80	12.00	10.87	10.00	2.05	.....	2.05	2.00	14.14	15.00	231
													15.00	261	
													16.50	43	
													15.00	302	
													16.50	639	
													17.00	642	
11.43	5.14	5.34	2.76	13.24	11.00	10.48	10.00	1.81	.....	*1.81	2.00	14.16	15.00	539

*Constituent falls below guarantee.

47-7-1900

ROCK AND POTASH

Sample number.	Manufacturer and Brand.	From Whom Sample Was Taken.
	E. FRANK COE CO., NEW YORK, N. Y.	
97	Dissolved Bone and Potash,	D. E. Brown, East Berlin,
	HENRY COPE & CO., LINCOLN UNIVERSITY, PA.	
206	Soluble Bone and Potash,	Passmore & Gillisple, Nottingham,
	JOSIAH COPE & CO., LINCOLN UNIVERSITY, PA.	
476	Soluble Bone and Potash,	Cope & Ivison, Oxford,
	CROCKER FERTILIZER & CHEMICAL CO., BUF- FALO, N. Y.	
165	} Dissolved Bone and Potash, {	O. B. Cross & Son, Clintonville,
440		C. R. Forbes, Albion,
	DETRICK FERTILIZER & CHEMICAL CO., BALTI- MORE, MD.	
546	P. & B. Special Fertilizer,	Levi Berkey, Edie,
	JAS. G. DOWNWARD & CO., COATESVILLE, PA.	
147	Soluble Bone and Potash,	J. T. L. Hare, Flemington,
	EUREKA FERTILIZER CO., PERRYVILLE, MD.	
215	Alkaline Bone and Potash,	Kirk & Yerkes, Nottingham,
	GREAT EASTERN FERTILIZER CO., RUTLAND, VT.	
250	} Soluble Bone & Potash Fertilizer, {	John Engle, Hummelstown,
338		J. M. Miller, Bills,
62		H. C. Moyer, Blooming Glen,
589		W. H. Hoffman, New Tripoli,
623		H. L. Robinson & Co., Punxsutawney, ..
	GRIFFITH & BOYD, BALTIMORE, MD.	
29	Potash Manure,	A. K. Straley, Hall,
110	XX Potash Manure,	A. M. Bechtel, Gitt's Run,
	HANOVER BONE FERTILIZER CO., HANOVER, PA.	
138	Hanover Dissolved Bone Phosphate,	Lebernigh & Ferree, Red Lion,
	HUBBARD & CO., BALTIMORE, MD.	
417	Soluble Bone and Potash,	Boettinger & Dietz, Danville,
	LAZARETTO GU'ANO CO., BALTIMORE, MD	
110	Dissolved Bone and Potash,	Z. H. Cashman, New Oxford,

Explanation of these tables see p. 27. †Composite sample.

FERTILIZERS—Continued.

Moisture in 100 pounds.	Phosphoric Acid in 100 Pounds.								Potash in 100 Pounds.				Computed commercial value at Department rating. (See p. 25.)	Selling price of 2,000 pounds at the point of selection.	Sample number.
	Soluble in water.	Reverted.	Insoluble.	Total.		Available.		Present as muriate.	Present as sulphate.	Total.					
				Found.	Guaranteed.	Found.	Guaranteed.			Found	Guaranteed.				
9.55	6.79	3.99	4.38	15.06	12.00	10.78	10.00	.....	1.99	*1.99	2.00	15.63	18.00	97
9.00	2.46	7.11	1.06	10.62	10.00	9.57	9.00	2.20	.....	2.20	2.00	13.05	15.00	205
11.83	10.27	3.08	.79	14.14	12.00	13.35	11.00	2.42	.....	2.42	2.00	16.38	12.50	476
7.20	6.81	5.67	1.06	13.54	11.00	12.48	10.00	2.00	.....	2.00	2.00	15.14	23.00 19.50	136
														440	
8.83	9.43	3.73	1.14	14.35	13.00	13.21	12.00	3.54	.....	3.54	3.00	17.50	16.50	545
7.17	1.93	5.53	2.55	10.06	.....	7.51	.....	2.85	.....	2.85	.....	12.97	22.00	147
11.34	3.93	5.42	2.88	12.23	12.00	*9.85	10.00	2.40	.....	2.40	2.00	13.96	15.00	2.5
9.09	7.08	4.59	1.63	13.30	12.00	11.67	11.00	2.20	.....	2.20	2.00	15.09	15.00 17.00 19.00 20.00	250
														323	
														63	
														589	
11.62	5.79	4.51	2.23	12.53	11.00	10.30	10.00	5.15	.....	*5.15	5.50	17.36	19.00	29
12.67	5.56	4.40	2.25	12.21	11.00	*9.96	10.00	5.16	.....	*5.16	5.50	17.11	19.00	119
10.90	7.80	3.80	.75	12.35	11.00	11.60	10.00	1.72	.....	*1.72	2.00	14.31	17.00	133
8.10	3.94	5.55	2.72	12.21	.....	*9.49	10.00	2.59	.....	2.59	2.00	14.20	16.00	417
12.83	5.16	5.68	1.33	12.17	11.00	10.84	10.00	2.25	.....	2.25	.....	14.29	14.50	110

*Constituent falls below guarantee.

ROCK AND POTASH

Sample number.		
	Manufacturer and Brand.	From Whom Sample Was Taken.
	MARYLAND FERTILIZER CO., BALTIMORE, MD.	
390	{ †Linden Super Phosphate, }	U. D. Brancher, Somerset, }
644		W. A. Nickodemus, Curry, }
645		W. A. Nickodemus, Curry, }
	MORO-PHILLIPS CHEMICAL CO., PHILADELPHIA, PA.	
240	{ †Alkaline Bone Phosphate, }	Wm. Woodmaker, Wind Gap, }
201		M. Gillis, Pennsdale, }
470		Patterson Ramsey, Chatham, }
	NIAGARA FERTILIZER WORKS, BUFFALO, N. Y.	
163	Niagara Dissolved Bone and Potash,	J. A. McKee, Clintonville,
	PACKER'S UNION FERTILIZER CO., NEW YORK, N. Y.	
371	{ †Wheat, Oats and Clover, }	Levi H. Miller, Reeder's, }
38		J. W. Glatfelter, Rossville, }
404		R. C. Hefley, Berlin, }
384	Wheat, Oats and Clover fertilizer,	N. D. Bowman, Stanton's Mills,
	READ FERTILIZER CO., NEW YORK, N. Y.	
155	Alkaline Bone or Bone and Potash,	Fields Bros., Wellsboro,
365	Alkaline Bone and Potash,	Jerome S. Williams, Stroudsburg,
	SCHAAL-SHELDON FERTILIZER CO., ERIE, PA.	
650	Dissolved Bone and Potash,	J. A. Einhiple, Albion,
	SCOTT FERTILIZER CO., ELKTON, MD.	
621	Tip Top Soluble Bone and Potash,	Miles Wigley, Mahaffey,
	SHARPLESS & CARPENTER, PHILADELPHIA, PA.	
34	{ †Soluble Bone and Potash, }	Ush & Brandt, Millerstown, }
233		B. F. Cocklin, Grantham, }
	H. H. SMYSER, YORK, PA.	
239	Chicago Crop Grower,	H. H. Smyser, York,
	STANDARD FERTILIZER CO., NEW YORK, N. Y.	
414	Standard Bone and Potash,	Edward Beyer, Danville,

For explanation of these tables see p. 37. †Composite sample.

FERTILIZERS—Continued.

Moisture in 100 pounds.	Phosphoric Acid in 100 Pounds.								Potash in 100 Pounds.				Computed commercial value at Department rating. (See p. 25.)	Selling price of 1,000 pounds at the point of selection.	Sample number.
	Soluble in water.	Reverted.	Insoluble.	Total.		Available.		Present as muriate.	Present as sulphate.	Total.					
				Found.	Guaranteed.	Found.	Guaranteed.			Found.	Guaranteed.				
7.92	6.83	5.02	1.15	13.00	12.00	11.85	11.00	2.26	.....	2.26	2.00	15.04	{ 15.50 17.50 15.00	390
9.97	8.59	3.61	.78	12.98	11.00	12.20	10.00	2.06	.....	2.06	2.00	15.13		644
														645	
10.52	5.14	5.39	1.67	12.20	12.00	10.53	10.00	2.26	.....	*2.26	10.00	14.24	{ 18.00 17.00 16.00	240
														201	
														470	
7.30	6.47	4.51	1.57	12.55	11.00	10.98	10.00	2.12	.....	2.12	.....	14.49	20.00	163
12.07	7.91	4.10	1.52	13.53	12.00	12.01	11.00	2.15	.....	2.15	2.00	15.31	{ 20.00 16.00 18.00	371
														38	
														404	
13.50	7.72	4.71	.82	13.25	12.00	12.43	11.00	2.10	.....	2.10	2.00	15.24	18.00	384
11.95	6.32	4.89	.49	11.70	10.50	11.21	10.00	1.33	.24	*1.57	2.00	13.69	19.00	155	
10.85	3.79	6.23	2.21	12.23	10.50	10.02	10.00	2.13	.....	2.13	2.00	13.93	17.00	265
12.35	2.74	6.72	2.30	11.77	11.00	*9.47	10.00	1.71	.....	*1.71	2.00	12.97	18.00	650
12.15	3.92	4.90	1.23	15.10	.....	13.82	11.00	1.93	.....	*1.93	2.00	16.21	20.00	621
10.66	5.31	6.06	1.01	12.41	12.00	11.40	10.00	2.60	.....	2.60	2.00	14.59	{ 15.00 16.00	84
														283	
12.41	2.54	5.56	3.36	11.43	.....	*8.10	10.00	2.06	.....	2.06	2.00	12.87	16.00	289
9.00	6.06	5.34	1.85	13.25	11.00	11.40	10.00	1.97	.....	*1.97	2.00	14.64	.....	414

*Constituent falls below guarantee.

ROCK AND POTASH

Sample number.	Manufacturer and Brand.	From Whom Sample Was Taken.
	STRAYER BROS., YORK, PA.	
26	Bone and Potash Mixture, SUSQUEHANNA FERTILIZER CO., BALTIMORE, M. D.	C. C. Kimmel, Mountain Top,
331	Susquehanna Alkaline Bone Phosphate, JAMES THOMAS, WILLIAMSPORT, PA.	C. Nels, Geistown,
76	} †Pure Dissolved Soluble Bone & Potash Phos- phate. {	L. M. Watts, Belleville,
313		Barker Bros., Ebensburg,
	TYGERT-ALLEN FERTILIZER CO., PHILADEL- PHIA, PA.	
217	Soluble Bone and Potash, M. E. WHEELER & CO., RUTLAND, VT.	E. B. Wood, Avondale,
323	} †H. G. Wheat and Clover, {	John S. Wetsell, Carrolltown,
543		Jacob S. Barkman, Somerset,
327		Clint. Doult, Norristown,
647	} †Wheat and Clover, {	A. McKinley, Franklin Corners,
	R. A. WOOLDRIDGE FERTILIZER CO., BALTI- MORE, MD.	
7	Liberty Bell Potash Mixture, YORK CHEMICAL WORKS, YORK, PA.	Franklin G. Evans, Keilton,
114	} †Dempwolf's Black Cross Phosphate and Pot- ash. {	J. L. Brodbeck, Hanover,
131		R. B. Hyson, Bridgeton,
112	} †Red Cross Phosphate and Potash, {	J. L. Brodbeck, Hanover,
136		R. B. Hyson, Bridgeton,
	ZELL GUANO CO., BALTIMORE, MD.	
34	Dissolved Bone Phosphate & Potash,	Oliver F. Arnold, Clear Spring,
428	} †Electric Phosphate, {	H. G. Supplee, Bloomsburg,
549		Peter Selp, Seltsville,

For explanation of these tables see p. 27. †Composite sample.

FERTILIZERS—Continued.

Moisture in 100 pounds.	Phosphoric Acid in 100 Pounds.								Potash in 100 Pounds.				Computed commercial value at Department rating. (See p. 25.)	Selling price of 2,000 pounds at the point of selection.	Sample number.
	Soluble in water.	Reverted.	Insoluble.	Total.		Available.		Present as muriate.	Present as sulphate.	Total.					
				Found.	Guaranteed.	Found.	Guaranteed.			Found.	Guaranteed.				
13.33	10.13	2.29	.63	13.05	.....	12.42	11.00	1.96	.....	*1.96	2.00	14.10	17.09	26
10.44	2.94	6.29	2.12	12.35	12.00	10.23	10.00	2.53	.....	2.53	2.00	14.38	23.00	331
13.40	9.53	2.39	.75	12.67	12.00	11.92	11.00	2.42	.....	2.42	2.00	15.40	18.75 18.00	76
														318	
9.69	4.60	6.09	.27	*10.96	11.50	10.69	10.00	1.95	.....	*1.95	2.00	12.46	17.00	217
11.53	7.81	3.57	1.23	12.61	12.00	11.38	11.00	2.38	.....	2.38	2.00	15.06	18.00 15.00	323
														543	
7.81	7.25	4.43	1.53	13.24	12.00	11.71	11.00	2.21	.....	2.21	2.00	15.12	..... 20.00	337
														647	
12.39	9.30	4.20	1.02	14.52	13.00	13.50	12.00	.93	1.99	*2.92	3.00	17.30	17.00	7	
10.87	2.37	6.29	2.64	*11.40	12.00	*8.76	10.00	2.19	.....	2.19	2.00	13.14	14.50 14.75	114
														121	
10.69	3.33	4.63	2.99	*11.50	12.00	*8.51	10.00	4.34	.....	*4.34	5.00	15.49	17.50 17.75	112
														120	
9.61	10.09	2.75	1.43	14.32	13.00	12.84	11.00	1.92	.....	*1.92	2.00	15.30	16.00	24
7.73	7.46	3.33	2.33	13.62	12.00	11.29	10.00	2.11	.....	2.11	2.00	15.06	18.00 18.90	423
														549	

*Constituent falls below guarantee.

DISSOLVED BONE

Furnishing Phosphoric

Sample number.

Manufacturer and Brand.

From Whom Sample Was Taken.

CLEVELAND PROVISION CO., CLEVELAND, OHIO.	
667	Packing House Fertilizer,
	Leonard Emig, Jr., Mendville,
LISTER'S AGRICULTURAL CHEMICAL WORKS, NEWARK, N. J.	
200	{ Celebrated Ground Bone Acidulated,
423	
	Passmore & Gillispie, Nottingham,
	J. A. Frouitz, Saegerstown,

For explanation of these tables see p. 27. †Composite sample.

FERTILIZERS.

Acid and Nitrogen.

Moisture in 100 pounds.	Phosphoric Acid in 100 Pounds.						Nitrogen in 100 Pounds.		Computed commercial value at Department rating. (See p. 25.)	Selling price of 2,000 pounds at the point of selection.	Sample number.	
	Soluble in water.	Reverted.	Insoluble.	Total.		Available.		(
				Found.	Guaranteed.	Found.	Guaranteed.					
4.10	.42	5.49	8.91	14.82	.....	5.91	.....	5.81	.....	35.47	.....	667
4.07	1.95	4.73	6.93	13.61	.....	*6.68	12.00	3.28	2.70	26.26	<div>26.00</div>	<div>209 432</div>

*Constituent falls below guarantee.

GROUND BONE

Furnishing Phosphoric

Sample number.	Manufacturer and Brand.		From Whom Sample Was Taken.	
	ALLEGHENY CITY FERTILIZER WORKS, ALLEGHENY, PA.			
166	Pure Raw Bone Meal,		A. H. Layton, Crawford's Corners,	
509	Raw Bone Meal,		L. & H. Hoberg, Sharpsburg,	
	ALLENTOWN MANUFACTURING CO., ALLENTOWN, PA.			
185	Pure Ground Bone,		Callahan & Weaver, Montoursville,	
	AMERICAN REDUCTION CO., PITTSBURGH, PA.			
184	Fine Ground Bone,		Horn & Hoover, Atlantic,	
	BAUGH & SONS COMPANY, PHILADELPHIA, PA.			
13	Bone Meal, warranted fine,		C. Frank Williamson, Media,	
	BERG COMPANY, PHILADELPHIA, PA.			
9	Raw Bone Fine,		J. W. Perkins, Elam,	
	BRADLEY FERTILIZER CO., BOSTON, MASS.			
239	Abattoir Bone,		A. F. Stutzman, Johnstown,	
	CAMBRIA FERTILIZER CO., JOHNSTOWN, PA.			
314	Pure Fine Ground Bone Dust,		H. A. Shoemaker, Ebensburg,	
	HENRY COPE & CO., LINCOLN UNIVERSITY, PA.			
310	Steamed Bone,		Passmore & Gillispie, Nottingham,	
	JOSIAH COPE & CO., LINCOLN UNIVERSITY, PA.			
463	Pure Ground Bone,		Chester Co. Ass'n of Farmers, Keltou,	
	CROCKER FERTILIZER & CHEMICAL CO., BUFFALO, N. Y.			
666	Pure Ground Bone,		Charles Stoltz, Meadville,	
	EUREKA FERTILIZER CO., PERRYVILLE, MD.			
2	Ground Bone,		London Grove Grange, Chatham,	
	JARECKI CHEMICAL CO., SANDUSKY, OHIO.			
449	Pure Ground Bone,		P. F. Cutter, West Green,	

For explanation of these tables see p. 27. †Composite sample.

FERTILIZERS.

Acid and Nitrogen.

Moisture in 100 pounds.	Mechanical Analysis.		Chemical Analysis.				Computed commercial value at Department rating. (See p. 25.)	Selling price of 2,000 pounds at the point of selection.	Sample number.
	Diameter less than $\frac{1}{16}$ inch, "fine."	Diameter greater than $\frac{1}{16}$ inch, "coarse."	Phosphoric Acid.		Nitrogen.				
			Found.	Guaranteed.	Found.	Guaranteed.			
5.55	57	43	23.55	22.00	3.02	2.50	27.43	.....	186
5.34	44	56	23.80	22.00	3.76	2.50	26.64	29.00	509
7.70	80	20	*23.36	25.00	*3.67	4.00	29.64	30.00	185
6.55	54	46	*19.44	22.00	3.83	3.29	24.93	28.00	184
6.77	90	10	*20.78	21.50	3.73	3.50	28.80	30.00	13
14.30	67	33	22.22	20.00	3.44	3.29	27.06	27.00	9
3.25	86	14	16.70	.....	*1.51	2.00	19.92	27.00	229
6.90	42	57	22.05	20.00	3.75	3.00	25.44	28.00	314
5.07	81	19	26.90	.....	2.20	.....	29.10	25.00	210
3.61	83	47	22.52	21.00	3.83	3.29	26.90	27.00	463
4.71	82	17	23.18	20.00	2.83	2.46	27.93	25.00	944
3.50	85	15	25.19	22.00	*2.39	2.47	28.64	25.00	2
7.00	70	30	*18.84	20.00	3.68	2.47	25.42	.....	449

*Constituent falls below guarantee.

GROUND BONE

Sample number.	Manufacturer and Brand.		From Whom Sample Was Taken.	
	LISTER'S AGRICULTURAL CHEMICAL WORKS, NEWARK, N. J.			
658	Celebrated Ground Bone,		W. M. Hawthorne, Sturgis,	
450	Pure Bone Meal,		D. H. Myers, West Green,	
51	Pure Raw Bone Meal,		Ruth & Rickabaugh, Newtown Square,	
	MORO-PHILLIPS CHEMICAL CO., PHILADELPHIA, PA.			
475	Steamed Bone,		Geo. W. Westcott, Oxford,	
	WM. C. NEWPORT CO., WILLOW GROVE, PA.			
457	Pure Bone Dust,		James E. Magill & Son, Bristol,	
	PACIFIC GUANO CO., NEW YORK, N. Y.			
443	Fine Ground Bone,		C. F. Myers, McKean,	
	E. RAUH & SONS FERTILIZER CO., INDIANAPOLIS, IND.			
349	Pure Ground Bone,		Geo. Barickman, Meadville,	
	SCHAAL-SHELDON FERTILIZER CO., ERIE, PA.			
177	Pure Bone Meal,		Seldon Brooks, Geneva,	
	SHARPLESS & CARPENTER, PHILADELPHIA, PA.			
225	Ground Bone,		Deweese & Bracken, Paoli,	
23	Pure Bone Meal,		Matthew Elliott & Co., Media,	
	SHENANDOAH FERTILIZER CO., SHENANDOAH, PA.			
278	Pure Ground Bone,		A. Cameron Bobb, Paxinos,	
	M. L. SHOEMAKER & CO., PHILADELPHIA, PA.			
17	Pure Raw Bone Meal,		Baugh & Rhodes, Media,	
	CHAS. A. SICKLER & BRO., WILKES-BARRE, PA.			
556	Pure Ground Bone,		Howard F. Brunges, Tunkhannock,	
	SWIFT & CO., CHICAGO, ILL.			
505	Bone Meal,		C. H. Schmucker, Friedens,	
219	Pure Bone Meal,		Wilson & Mendenhall, Toughkenamon,	

For explanation of these tables see p. 27. †Composite sample.

FERTILIZERS—Continued.

Mixture in 100 pounds.	Mechanical Analysis.		Chemical Analysis.				Computed commercial value at Department rating. (See p. 25.)	Selling price of 2,000 pounds at the point of selection.	Sample number.
	Diameter less than $\frac{1}{16}$ inch, "fine."	Diameter greater than $\frac{1}{16}$ inch, "coarse."	Phosphoric Acid.		Nitrogen.				
			Found.	Guaranteed.	Found.	Guaranteed.			
4.33	63	37	14.24	13.00	3.17	2.70	20.43	23.00	653
4.27	67	33	23.94	23.00	2.71	2.68	16.64	.....	450
4.51	64	36	24.05	23.00	2.84	2.63	26.76	27.00	51
4.06	91	9	*17.21	18.00	2.74	2.47	23.61	26.00	475
5.55	66	34	23.09	22.00	*3.42	3.71	27.54	29.00	457
5.22	83	12	14.30	.....	2.14	2.00	19.63	25.00	443
4.97	76	24	18.10	18.00	*2.15	2.47	21.23	27.50	349
5.30	56	44	24.14	22.00	3.19	2.85	26.33	.....	177
5.77	63	38	18.00	.....	2.63	.....	21.86	30.00	235
5.26	77	23	*20.56	20.61	3.34	.....	26.53	35.00	28
10.00	74	26	*20.39	22.00	*1.96	2.33	22.93	28.00	273
6.02	56	14	25.15	20.61	3.42	3.29	21.05	22.00	17
4.03	83	17	27.13	23.00	*2.21	2.47	29.53	30.00	536
4.28	98	7	26.23	25.00	2.76	3.50	21.06	26.00	505
4.03	87	13	25.24	23.00	*2.83	3.75	29.35	25.00	314

*Constituent falls below guarantee.

GROUND BONE

Sample number.	Manufacturer and Brand.		From Whom Sample Was Taken.	
	JAMES THOMAS, WILLIAMSPORT, PA.			
146	Pure Animal Bone,		McCalmont & Co., Bellefonte,	
	R. A. WOOLDRIDGE FERTILIZER CO., BALTI- MORE, MD.			
4	Tuckahoe Bone Meal,		Franklin G. Evans, Kelton,	

For explanation of these tables see p. 27. †Composite sample.

FERTILIZERS—Continued.

Moisture in 100 pounds.	Mechanical Analysis.		Chemical Analysis.				Computed commercial value at Department rating. (See p. 25.)	Selling price of 2,000 pounds at the point of selection.	Sample number.
	Diameter less than $\frac{1}{16}$ inch, "fine."	Diameter greater than $\frac{1}{16}$ inch, "coarse."	Phosphoric Acid.		Nitrogen.				
			Found.	Guaranteed.	Found.	Guaranteed.			
6.07	75	25	15.91	.....	2.78	.....	21.61	30.00	146
7.25	75	25	17.32	14.00	2.35	2.47	21.61	24.00	4

*Constituent falls below guarantee.

ACIDULATED ROCK

Furnishing

Sample number.	Manufacturer and Brand.	From Whom Sample Was Taken.
	ARMOUR FERTILIZER WORKS, CHICAGO, ILL.	
442	†Star Phosphate,	John F. Chisholm, Sterrettania,
536		J. Hoffman & Son, Jenners,
	BAUGH & SONS CO., PHILADELPHIA, PA.	
455	†H. G. Acid Phosphate,	Deweese & Bracken, Paoli,
103		J. W. Ruff, New Oxford,
676		A. Gaddis & Co., Uniontown,
	A. H. BLAKER & CO., FOX CHASE, PA.	
24	Blaker's Wonder,	C. P. Wotring, Unionville,
	BOWKER FERTILIZER CO., BOSTON, MASS.	
274	Apex Bone,	Alvin Sax, Effort,
164	Apex Bone Phosphate,	S. & J. W. Stroh, Sunbury,
180	†Dissolved Bone Phosphate,	J. R. Hood, Colton,
154		Bailey & Converse, Wellaboro,
276		Alvin Sax, Effort,
	BRADLEY FERTILIZER CO., NEW YORK, N. Y.	
327	†Soluble Dissolved Bone,	A. F. Stutzman, Johnstown,
168		I. B. Miller, Wesley,
514		S. J. Saint, Sharpsburg,
668		J. H. Davidson & Son, Franklin,
	CHEMICAL CO. OF CANTON, BALTIMORE, MD.	
267	†Baker's Dissolved Bone Phosphate,	L. Campbell, Sunbury,
479		Morris Nauman, Stroudsburg,
262		J. A. Romberger, Elizabethtown,
536		Iosiah Specht, Kantner,
638		H. M. Gray, Tyrone,
672		King Bros., Uniontown,
641		H. L. Stultz, Duncansville,
648		Skyles Miller & Co., Martinsburg,

For explanation of these tables see p. 27. †Composite sample.

PHOSPHATES.

Phosphoric Acid.

Moisture in 100 pounds.	Phosphoric Acid in 100 Pounds.							Computed commercial value at Department rating. (See p. 25.)	Selling price of 2,000 pounds at the point of selection.	Sample number.
	Soluble in water.	Reverted.	Insoluble.	Total.		Available.				
				Found.	Guaranteed.	Found.	Guaranteed.			
12.81	11.39	5.55	1.21	18.15	19.00	16.94	14.00	15.18	{ 15.00 16.50	442 536
9.20	11.18	4.17	1.14	16.49	.....	15.35	14.00	14.18	{ 14.00 13.00 14.00	455 108 676
9.20	12.02	3.42	.60	16.04	.....	15.44	.....	14.12	12.50	494
10.62	2.49	8.37	2.51	13.37	10.00	10.86	9.00	10.92	12.50	374
7.90	2.87	6.28	3.35	13.50	10.00	10.15	9.00	10.96	.....	264
11.45	6.29	5.89	2.51	14.60	12.00	12.18	11.00	12.18	{ 16.00 18.00 12.00	180 154 376
7.37	10.29	5.32	1.62	17.23	.....	15.61	14.00	14.41	{ 15.00 12.00 15.00 20.00	237 166 514 661
8.64	11.20	4.50	.97	16.67	16.00	15.70	14.00	14.31	{ 13.00 15.00 14.00 16.00 15.00 12.50	261 479 262 536 638 672
9.22	11.01	4.34	1.06	16.43	16.00	15.35	14.00	14.13	{ 15.00 15.00	641 642

*Constituent falls below guarantee.

ACIDULATED ROCK

Sample number.	Manufacturer and Brand.		From Whom Sample Was Taken.	
	CLARK'S COVE FERTILIZER CO., NEW YORK, N. Y.			
268	Acid Phosphate,		A. Cameron Bobb, Paxinos,	
574	Atlas,		Fowler Ellis, Franklindale,	
271			A. Cameron Bobb, Paxinos,	
581			Solomon Livingood, Joanna,	
	E. FRANK COE CO., NEW YORK, N. Y.			
99	High Grade Acid Phosphate,		D. E. Brown, East Berlin,	
242	High Grade Acid Phosphate,		Wm. H. Mengel, Saylorsburg,	
	HENRY COPE & CO., LINCOLN UNIVERSITY, PA.			
223	Acid Phosphate,		E. B. Wood, Avondale,	
	JOSIAH COPE & CO., LINCOLN UNIVERSITY, PA.			
467	Acidulated Phosphate,		Chester Co. Ass'n of Farmers, Kelton,	
	CROCKER FERTILIZER & CHEMICAL CO., BUFFALO, N. Y.			
489	Dissolved Bone Phosphate,		C. R. Forbes, Albion,	
	CUMBERLAND BONE PHOSPHATE CO., PORTLAND, ME.			
286	Cumberland Dissolved Bone Phosphate,		J. J. Zimmerman, Jenner township,	
	DETRICK FERTILIZER & CHEMICAL CO., BALTIMORE, MD.			
20	Dissolved S. C. Bone,		Wm. Lindsay, Newport,	
	LOUIS F. DETRICK; BALTIMORE, MD.			
207	Orchilla Guano,		Passmore & Gillespie, Nottingham,	
	EUREKA FERTILIZER CO., PERRYVILLE, MD.			
3	P. & P. Super Phosphate,		Londongrove Grange, Chatham,	
	FARMER'S UNION FERTILIZER CO., NEW YORK, N. Y.			
91	Acidulated Bone,		J. W. Klinepetir, New Bloomfield,	
	GREAT EASTERN FERTILIZER CO., RUTLAND, VT.			
567	Dissolved Bone,		M. A. Cramer, Monroeton,	

*For explanation of these tables see p. 27. †Composite sample.

PHOSPHATE—Continued.

Moisture in 100 pounds.	Phosphoric Acid in 100 Pounds.								Computed commercial value at Department rating. (See p. 25.)	Selling price of 2,000 pounds at the point of selection.	Sample number.
	Soluble in water.	Reverted.	Insoluble.	Total.		Available.					
				Found.	Guaranteed.	Found.	Guaranteed.				
2.62	3.88	4.81	2.72	11.41	.....	8.09	.....	9.88	13.00	268
3.92	3.34	6.23	1.22	16.89	15.00	15.17	14.00	13.75	{ 13.00 14.00 13.50	574	
										271	
										581	
10.28	2.75	4.50	2.45	16.70	.....	*13.25	16.00	12.45	15.00	99
7.87	10.41	5.06	1.42	16.89	.....	*15.47	16.00	14.27	12.00	242
9.70	2.97	5.27	.80	15.04	15.00	14.24	14.00	13.12	12.00	223	
11.81	11.89	3.73	1.03	16.03	15.00	15.63	14.00	14.23	11.00	467	
6.59	9.90	6.32	1.61	17.83	15.00	16.22	14.00	14.72	13.00	439	
12.19	11.31	4.08	1.01	16.35	15.00	15.34	14.00	14.13	14.00	386	
11.70	10.18	4.42	1.45	16.05	15.00	14.90	14.00	13.71	14.00	90	
4.40	.03	2.53	11.19	15.05	14.00	3.86	.....	9.55	15.00	207
10.52	9.32	4.58	1.96	16.38	16.00	14.40	14.00	13.74	12.00	3	
3.22	12.39	3.52	1.43	17.04	.....	16.21	.....	14.94	14.00	91
7.37	11.32	4.57	1.17	17.06	16.00	15.89	14.00	14.53	12.00	567	

*Constituent falls below guarantee.

ACIDULATED ROCK

Sample number.	Manufacturer and Brand.	From Whom Sample Was Taken.
422	Dissolved Bone Fertilizer,	Albert H. Morris, Danville,
	GRIFFITH & BOYD, BALTIMORE, MD.	
31	} †High Grade Acid Phosphate, {	A. K. Straley, Hall, {
32		H. R. Beale, Oriental, {
113		A. M. Bechtel, Gitt's Run, {
32		A. K. Straley, Hall, {
123	} †Original Super Phosphate, {	Callahan & Weaver, Montoursville, {
406		E. A. Slagle, Paxinos, {
	S. M. HESS & BRO., PHILADELPHIA, PA.	
491	H. G. Acid Phosphate,	Wm. H. Boyer, Minnichs,
	HUBBARD & CO., BALTIMORE, MD.	
416	H. G. Soluble S. C. Phosphate,	Boettinger & Dietz, Danville,
	JARECKI CHEMICAL CO., SANDUSKY, OHIO.	
179	C. O. D. Phosphate,	Eugene Burnett, Utica,
	LAZARETTO GUANO CO., Baltimore, Md.	
109	Dissolved Bone Phosphate,	Z. H. Cashman, New Oxford,
	MILSOM RENDERING & FERTILIZER CO., EAST BUFFALO, N. Y.	
356	} †14 per cent. Acid Phosphate, {	Lord & Drake, Cambridge Springs, {
596		Wm. F. Snyder, Stony Run, {
	MORO-PHILLIPS CHEMICAL CO., PHILADEL- PHIA, PA.	
64	Cereal Bone Phosphate,	Frets & Slotter, Perkaskie,
211	} †Soluble Bone, {	P. Moran, Gallitsin, {
426		H. G. Supplee, Bloomsburg, {
126		M. Gilles, Pennsdale, {
145		John W. Stuart, State College, {
241	} †Soluble Bone Phosphate, {	Wm. Woodmaker, Wing Gap, {
266		L. Campbell, Sunbury, {

For explanation of these tables see p. 27. †Composite sample.

FERTILIZERS—Continued.

Moisture in 100 pounds.	Phosphoric Acid in 100 Pounds.							Computed commercial value at Department rating. (See p. 25.)	Selling price of 2,000 pounds at the point of selection.	Sample number.
	Soluble in water.	Reverted.	Insoluble.	Total.		Available.				
				Found.	Guaranteed.	Found.	Guaranteed.			
10.60	12.01	2.59	.69	16.29	16.00	15.60	14.00	14.26	15.00	422
11.98	10.44	2.82	2.16	16.43	15.00	14.27	14.00	12.83	{ 12.00 13.00 12.00 12.00 14.00 12.50	31
										83
										118
9.80	7.17	5.12	2.63	15.03	12.00	12.35	12.00	12.44		33
										192
										408
7.23	8.29	7.29	1.08	16.76	15.00	15.68	14.00	14.00	14.00	481
15.55	12.15	2.55	.46	15.16	.....	14.70	14.00	12.65	14.00	416
14.41	8.45	6.29	2.06	16.90	15.00	14.84	14.00	12.37	16.00	170
12.15	12.45	2.06	.58	16.09	15.00	15.51	14.00	14.22	12.50	100
8.25	8.24	6.01	1.20	15.55	15.00	14.35	14.00	12.34	{ 17.00 16.00	256
										595
5.15	9.23	4.25	.77	14.25	.....	13.48	.....	12.69	11.00	64
8.56	10.22	5.25	.94	16.61	15.00	15.67	14.00	14.12	{ 14.10 15.00 16.00 14.50 12.50 12.00	311
										424
										196
										145
9.91	10.50	4.29	1.00	16.39	15.00	15.39	14.00	14.06		241
										266

*Constituent falls below guarantee.

ACIDULATED ROCK

Sample number.	Manufacturer and Brand.	From Whom Sample Was Taken.
	OHIO FARMER'S FERTILIZER CO., COLUMBUS, OHIO.	
172	Superior Phosphate,	Eugene Burnett, Utica,
	PACKERS' UNION FERTILIZER CO., NEW YORK, N. Y.	
389	} †Banner Wheat Grower,	} Levi H. Miller, Readers,
388		
406		
	R. H. POLLOCK, BALTIMORE, MD.	
634	Dissolved S. C. Bone,	J. A. C. Rider, Tyrone,
	READ FERTILIZER CO., NEW YORK, NEW YORK.	
180	Acid Phosphate,	Fields Bros., Wellsboro,
386	} †Dissolved Bone Fertilizer,	} Jerome S. Williams, Stroudsburg,
609		
	JOHN S. REESE & CO., BALTIMORE, MD.	
35	} †Elm Phosphate,	} N. H. Spangler, Rossville,
538		
	ISAAC ROBINSON, BALTIMORE, MD.	
127	H. G. Soluble Phosphate,	A. G. Galbraith, Woodbine,
	SCHAAL-SHELDON FERTILIZER CO., ERIE, PA.	
613	Dissolved Bone,	W. Sherline, Willmore,
	SCIENTIFIC FERTILIZER CO., PITTSBURGH, PA.	
162	Scientific Dissolved Bone,	James Shaffer, Cyrus,
	SHARPLESS & CARPENTER, PHILADELPHIA.	
21	} †Acid Phosphate,	} Matthew Elliott & Co., Media,
83		
	M. L. SHOEMAKER & CO., PHILADELPHIA, PA.	
677	Dissolved S. C. Rock,	N. W. Stroup, Elizabethtown,
	E. A. SLAGLE, PAXINOS, PA.	
413	H. G. Acid Phosphate,	E. A. Slagle, Paxinos,

For explanation of these tables see p. 27. †Composite sample

FERTILIZERS—Continued.

Moisture in 100 pounds.	Phosphoric Acid in 100 Pounds.							Computed commercial value at Department rating. (See p. 25.)	Selling price of 2,000 pounds at the point of selection.	Sample number.
	Soluble in water.	Reverted.	Insoluble.	Total.		Available.				
				Found.	Guaranteed.	Found.	Guaranteed.			
14.72	7.32	5.01	1.60	13.93	14.00	*12.33	12.00	12.07	16.00	173
10.38	4.02	6.58	1.53	12.13	11.00	10.00	10.00	10.00	{ 15.00 17.00 18.00	{ 289 288 406
11.50	11.70	3.31	.79	15.80	15.00	15.01	14.00	12.39	14.00	624
9.95	12.19	2.72	.39	16.30	14.50	15.91	14.00	14.47	12.00	160
9.25	8.86	6.42	1.37	16.65	.....	15.28	.....	12.94	{ 15.00 12.25	{ 286 609
11.46	11.96	3.80	1.12	16.38	15.00	15.26	14.00	14.29	{ 15.00 16.00	{ 35 533
8.65	11.01	4.23	1.17	16.51	.....	15.24	14.00	14.18	12.00	127
7.63	1.36	8.55	2.54	12.45	11.00	*0.91	10.00	10.23	15.00	612
12.07	4.65	7.34	1.12	13.12	.....	11.09	.....	11.36	15.00	162
10.41	9.08	5.42	1.25	15.76	15.00	14.51	14.00	13.45	{ 14.00 14.00	{ 21 83
2.42	7.72	5.96	5.34	19.54	.....	13.70	.....	14.46	10.00	677
11.27	11.00	3.64	.62	15.86	.....	15.24	14.00	12.96	12.00	413

*Constituent falls below guarantee.

ACIDULATED ROCK

Sample number.	Manufacturer and Brand.	From Whom Sample Was Taken.
	SOUTHERN FERTILIZER CO., YORK, PA.	
296	Dissolved Bone Phosphate,	Wagner & Earnst, York,
	STANDARD FERTILIZER CO., NEW YORK, N. Y.	
415	Standard Dissolved Bone Phosphate,	Edward Beyer, Danville,
	SUSQUEHANNA FERTILIZER CO., BALTIMORE, MD.	
564	Soluble Bone Phosphate,	B. A. Cramer, Monroeton,
	SWIFT & CO., CHICAGO, ILL.	
504	Diamond Phosphate,	C. H. Schmucker, Friedens,
	JAMES THOMAS, WILLIAMSPORT, PA.	
430	Pure Dissolved S. C. Bone,	J. B. Smith, Washingtonville,
317	} †Pure Dissolved S. C. Bone Phosphate, {	Barker Bros., Ebensburg,
74		L. M. Watts, Belleville,
618		E. J. Hughes, Lilly,
	TYGERT-ALLEN FERTILIZER CO., PHILADELPHIA, PA.	
570	Dissolved Bone Phosphate,	J. Y. L. Ward, South Towanda,
12	Sam'l H. Howitz's Acid Phosphate,	Marshall Matlock, Cheyney,
	R. A. WOOLDRIDGE FERTILIZER CO., BALTIMORE, MD.	
6	Florida Acid Phosphate,	Franklin G. Evans, Kelton,
	ZELL GUANO CO., BALTIMORE, MD.	
33	} †Dissolved Bone Phosphate, {	Oliver F. Arnold, Clear Spring,
548		Peter Seip, Somerset,
547		Peter Seip, Somerset,

For explanation of these tables see p. 27. †Composite sample

FERTILIZERS—Continued.

Moisture in 100 pounds.	Phosphoric Acid in 100 Pounds.								Computed commercial value at Department rating. (See p. 26.)	Selling price of 2,000 pounds at the point of selection.	Sample number.
	Soluble in water.	Reverted.	Insoluble.	Total.		Available.					
				Found.	Guaranteed.	Found.	Guaranteed.				
11.23	11.01	3.76	.74	15.51	15.00	14.77	14.00	12.65	14.00	296	
9.39	11.12	4.14	1.39	16.66	15.00	15.27	14.00	14.19	.....	415
6.25	11.76	3.90	1.01	16.67	15.00	15.66	14.00	14.36	15.00	564	
6.25	2.56	3.30	1.81	12.67	11.00	10.86	10.00	10.66	12.00	504	
11.40	12.71	3.29	.32	16.42	16.00	16.10	14.00	14.49	.....	420
11.42	11.46	2.52	1.00	16.04	16.00	15.04	14.00	12.96	{ 16.00 15.00 16.00	317	
										74	
										613	
10.30	11.01	5.50	.56	17.07	15.00	16.51	14.00	14.65	26.00	570	
11.34	10.14	4.10	.99	15.04	15.00	14.24	14.00	12.26	14.00	12	
11.22	11.23	3.20	1.39	15.87	.....	14.48	14.00	12.72	12.00	6
8.95	12.05	2.76	1.51	17.32	16.00	15.81	14.00	14.79	{ 15.00 14.00 14.00	23	
9.95	12.23	2.06	.87	17.51	.....	16.94	.....	15.25		548
									14.00	547	

*Constituent falls below guarantee.

MISCELLANEOUS

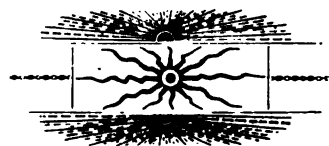
Sample number.	Manufacturer and Brand.		From Whom Sample Was Taken.	
	JAMES BONDAY, JR., & CO., BALTIMORE, MD.			
88	Old Reliable Brand—Genuine Kainit,		H. L. Tresaler, Newport,	
	HUBBARD & CO., BALTIMORE, MD.			
418	Kainit,		Boettinger & Diets, Danville,	
	SHARPLESS & CARPENTER, PHILADELPHIA.			
85	Kainit,		Uish & Brandt, Millerstown,	

For explanation of these tables see p. 27. †Composite sample.

FERTILIZERS.

Moisture in 100 pounds.	Potash in 100 Pounds. (Water Soluble.)				Computed commercial value of 2,000 pounds at Department rating. (See p. 25.)	Selling price of 2,000 pounds at the point of selection.	Sample number.
	Present as muriate.	Present as sulphate.	Total.				
			Found.	Guaranteed.			
4.43	12.20	.....	12.20	.....	14.44	15.00	83
.50	12.58	.....	12.58	12.00	15.87	15.00	112
12.75	12.91	.....	12.91	12.42	16.18	14.00	85

*Constituent falls below guarantee.



ANALYSES OF FALL SAMPLES.

Tabulated Analyses of Commercial Fertilizers

FROM

SAMPLES SELECTED BY SPECIAL AGENTS

OF THE

Pennsylvania Department of Agriculture.

**Analyses by DR. WILLIAM FREAR, Chemist of the Department, and of the State College Experiment Station,
State College, Pa.**

SAMPLES SELECTED FROM AUGUST 1, 1900, TO DECEMBER 31, 1900.

THE CHEMIST'S REPORT OF ANALYSES OF FERTILIZERS MADE FROM AUGUST 1, TO DECEMBER 31, 1900.

—

Hon. John Hamilton, Secretary of Agriculture:

Sir: During the Fall of this year, there were received from the several authorized sampling agents, 711 fertilizer samples, of which 301 were analyzed, the remainder being rejected from the fact that they had been examined last season. Where brands were represented by two or more samples, these were united into a single composite sample for analysis.

The samples analyzed are grouped as follows:

Complete (containing phosphoric acid, potash and nitrogen),	130
Dissolved bone (containing phosphoric acid and nitrogen), ...	2
Rock and potash (containing phosphoric acid and potash), ...	33
Dissolved rock (containing phosphoric acid only),	31
Ground bone (containing phosphoric acid and nitrogen),	17
Miscellaneous (German potash salts),	2

215

As these figures show, 86 samples were merged with others, to form composites.

The methods of analysis employed are fully described in the report of the Spring analyses and require no further comment at this time.

As heretofore, the statement of guaranty for comparison with figures found by analysis, gives only the lower figures stated in the manufacturer's brand for the several components of the fertilizer. Where the statement was made in terms of amonia, the percentage is reduced to the corresponding nitrogen percentage by multiplication by the factor 0.824. Conversely, if a consumer is desirous to translate into terms of ammonia the nitrogen percentages given in the list of analyses, it may be done by multiplying the nitrogen percentages by the factor 1.214.

The summary of the analyses made this season is as follows, omitting the miscellaneous fertilizers:

	Complete fertilizers.	Dissolved bone.	Rock and potash.	Dissolved rock.	Ground bone.
Number of analyses,	180	2	33	31	17
Moisture, per cent.,	9.13	4.59	10.83	9.75	5.45
Phosphoric acid:					
Total, per cent.,	11.33	15.33	12.73	15.73	22.52
Soluble, per cent.,	4.96	2.97	5.42	8.33	.....
Reverted, per cent.,	3.83	4.24	5.38	5.18	.....
Insoluble, per cent.,	2.54	8.12	1.93	2.22	.....
Potash, per cent.,	2.85	.....	2.36	.....	.....
Nitrogen, per cent.,	1.46	1.24	.....	.....	2.13
Mechanical analysis of bone:					
Fine, per cent., .....	.....	.....	.....	.....	69
Coarse, per cent., .....	.....	.....	.....	.....	31
Commercial valuation,	\$24 03	\$22 74	\$14 63	\$13 11	\$26 87
Average selling price,	23 22	23 50	18 11	13 96	28 73
Commercial value of samples whose selling price is ascertained,	23 84	22 74	14 63	13 11	28 73

Compared with the average composition of the fertilizers sold in the fall of 1899, little noteworthy difference is shown by these analyses, except that the dissolved rocks were to a somewhat smaller degree composed of soluble phosphoric acid; the ground bone also contained a trifle less nitrogen.

Compared with the goods sold last Spring, the complete fertilizers show the usual difference between the goods of the Spring and Fall, the fertilizers made for the Fall trade containing considerably less potash and nitrogen, because less intended for use in vegetable growing.

The cases of deficiency in which the samples fell at one or more points below the guaranteed composition to an amount of two-tenths per cent. or more, may be grouped as follows:

	Complete fertilizers.	Dissolved bone.	Rock and potash.	Dissolved rock.	Ground bone.
Deficient in four constituents,	1	.....	.....	.....	.....
Deficient in three constituents,	6	.....	1	.....	.....
Deficient in two constituents,	12	.....	2	1	.....
Deficient in one constituent,	34	1	8	5	2
Total samples in which deficiency occurred, ..	53	1	11	6	2

The proportion of samples falling below guarantee in each of the principal classes of fertilizers during the past four seasons are given below in percentages.

	Spring, 1899.	Fall, 1899.	Spring, 1900.	Fall, 1900.
Complete fertilizers,	38.4	33.7	42.0	40.8
Dissolved bone,	50.0	14.3	*50.0	*50.0
Rock and potash,	19.1	34.2	23.2	33.3
Dissolved rock,	13.8	14.5	5.4	19.4
Ground bone,	18.4	25.3	36.7	11.8
All classes except miscellaneous,	30.9	29.2	35.2	34.3

*Only two samples analyzed.

The extent to which deficiencies occur is greater than it should be. It is to be considered, however, that about two-thirds of the samples in which deficiency occurred, were thus affected at only one point. This often results from imperfect mixing in the factory, rather than from any deliberate action on the part of the manufacturer, and sometimes occurs where the formula used in compounding the goods should ensure a safe margin of value above that guaranteed. As compared with 1899, both seasons of 1900 show a greater proportion of cases of deficiency.

The actual selling prices and the valuations based on market conditions for the six months preceding March 1, 1899, are given below:

	Selling price.	Valuation.	Excess of selling price over valuation.
Complete fertilizers:			
1899, Spring,	\$33 69	\$24 70	\$ 1 10
1899, Fall,	22 98	23 42	-1 44
1890, Spring,	25 38	24 61	77
1890, Fall,	23 22	23 84	-62
Dissolved bone:			
1899, Spring,	21 75	21 81	-6
1899, Fall,	19 00	21 12	-2 12
1890, Spring,	26 00	20 87	4 87
1890, Fall,	22 50	22 74	76
Rock-and-potash:			
1899, Spring,	16 83	15 16	1 67
1899, Fall,	17 28	14 53	2 75
1900, Spring,	17 35	14 71	2 64
1900, Fall,	18 11	14 63	3 48
Dissolved rock:			
1899, Spring,	13 36	14 02	-67
1899, Fall,	12 64	13 12	-49
1890, Spring,	13 57	12 48	99
1890, Fall,	12 96	13 11	85
Ground bone:			
1899, Spring,	26 67	23 11	1 44
1899, Fall,	24 98	27 23	-2 25
1890, Spring,	23 42	25 91	-2 51
1890, Fall,	28 73	26 87	1 86

Leaving out of consideration the class, dissolved bone, because of the small number of samples represented, it is noteworthy that in all cases except the complete fertilizers, the average selling price exceeds the valuation; particularly is this the case with rock-and-potash and ground bone. As explained in discussing the Spring results for this year, the higher selling prices are to be explained by a partial reorganization of the retail trade whereby prices are more fully protected from the effects of competition, rather than by any increase in wholesale prices of materials, the latter changes having already been allowed for in the readjustment of the schedule of valuations adopted for the year. The falling off in the relative prices of complete fertilizers since last Spring is possibly due, in part, to conditions of consumption and, in part, to an unexpected revival of competition.

Respectfully submitted,

WM. FREAR.

December 31, 1900.

COMPLETE Furnishing Phosphate Ac

Sample number.	Manufacturer and Brand.	From Whom Sample Was Taken.
	ALLEGHENY CITY FERTILIZER WORKS, ALLEGHENY, PA.	
1123	†Banner Phosphate,	Enos Barkey, Evans City, Pa.,
1252		T. and F. Hobarg, Sharpsburg, Pa.,
765		D. G. Shoemaker, Piolett, Pa.,
1286		Moses Clark, Haydenville (P. O. Uniontown),
	ARMOUR FERTILIZER WORKS, CHICAGO, ILL.	
1377	Ammoniated Bone with Potash,	Isaac W. Holcombe, New Hope, Pa.,
808	†Wheat Special,	J. L. Ritter & Son, Newport, Pa.,
744		J. E. Heagy, Roaring Springs, Pa.,
1038		E. A. Slagle, Paxinos, Pa.,
	R. S. AUCKER, SHAMOKIN, PA.	
916	Grade A Bone and Slaughter House Phosphate,	John Penny, Dry Valley, Pa.,
833	Grade Bone and Slaughter House Phosphate,	George Weymouth, Rote, Pa.,
	BAUGH & SONS CO., 20 S. DEL. AVE., PHILA.	
933	Wheat Fertilizer for Wheat and Grass,	W. P. Hay, Somerset (P. O. Lavensville), ..
	BERG CO., PHILADELPHIA, PA.	
1233	†Special \$25 Bone Manure,	Geo. E. Hoffman, Cresona, Pa.,
1352		Frank Rees, Aldham, Pa.,
855		Spracker & Ganss, Lancaster, Pa.,
1368		Chas. T. Torr, Langhorne, Pa.,
	D. BLOCHER & CO., GETTYSBURG, PA.	
713	†H. G. Super Phosphate of Bone,	J. F. Harshberger, Lewistown, Pa.,
786		Harry Riddlemoser, E. Berlin, Pa.,
	BOWKER FERTILIZER CO., BOSTON AND NEW YORK.	
1119	Wood Ash Fertilizer,	J. G. and W. Campbell, Butler, Pa.,

For explanation of these tables see page 27. †Composite sample.

FERTILIZERS.

id, Potash and Nitrogen.

Moisture in 100 pounds.	Phosphoric Acid in 100 Pounds.								Potash in 100 Pounds. (Water Soluble.)				Nitrogen in 100 Pounds.		Computed commercial value of 2,000 pounds at Department rating. (See p. .)	Selling price of 2,000 pounds at the point of selection.	Sample number.
	Soluble in water.	Reverted.	Insoluble.	Total.		Available.		Present as muriate.	Present as sulphate.	Total.		Found.	Guaranteed.				
				Found.	Guaranteed.	Found.	Guaranteed.			Found.	Guaranteed.						
6.25	4.87	3.41	1.56	9.84	8.00	8.28	7.00	2.63	.....	2.63	2.00	.90	.83	20.74	23.00	1123
															18.00	1262	
															22.00	766	
															20.00	1286	
8.09	4.30	3.98	1.64	9.92	7.5	8.28	6.00	2.36	.....	2.36	2.00	3.34	2.47	29.49	26.00	1377
5.58	1.23	6.18	1.67	9.08*	10.00	7.41*	8.00	1.10	.....	1.10	1.00	.95	.82	18.06	21.00	808
															20.00	744	
															20.00	1036	
6.97	2.36	4.23	3.62	10.27*	11.39	6.65*	8.18	3.53	.....	3.53*	3.73	1.58*	1.75	23.17	25.00	916
8.47	2.28	4.76	2.48	9.52*	11.38	7.04*	8.18	3.62	.....	3.62	3.73	.91*	1.75	20.49	23.00	838
10.52	4.67	4.14	2.28	11.00	.....	8.81	8.00	2.29	.....	2.29	2.00	1.77	1.65	24.44	.....	963
																25.00	1233
8.06	5.44	2.67	3.94	12.05	.....	8.11	7.00	2.58	.....	2.58	2.00	1.68	1.65	24.63	25.00	1353
															25.00	855	
															25.00	1368	
9.68	8.02	3.13	2.38	13.53	12.00	11.15	10.00	1.34	.....	1.34*	1.50	1.07*	1.24	23.85	20.00	713
															20.00	786	
8.34	.23	7.74	6.92	14.89	.....	7.97	.....	.40	1.87	2.27	.....	1.59	.....	24.97	28.00	1119

*Constituent falls below guarantee.

COMPLETE FERTI

Sample number.	Manufacturer and Brand.	From Whom Sample Was Taken.
BRADLEY FERTILIZER CO., NEW YORK.		
1094	{ Dissolved Bone with Potash,	C. M. Young, Elk Lake, Pa.,
802		L. M. Shuler, Liverpool, Pa.,
1254		S. J. Saint, Sharpsburg, Pa.,
1092	Potato Fertilizer,	F. E. Baron, S. Monroë, Pa.,
BRUMFIELD & FOSTER, COLORA, CECIL CO., MARYLAND.		
838	Ammoniated Bone Phosphate,	D. R. Miller, Petersburg, Pa.,
840	Hard Times Ammoniated Phosphate,	D. R. Miller, Petersburg, Pa.,
CHEMICAL CO. OF CANTON, BALTIMORE, MD.		
829	Baker's Special,	Furst Bros., Cedar Springs, Pa.,
968	Baker's Wheat, Corn and Grass Mixture,	Forstman Bros., Elvira, Pa.,
846	{ Harrow Brand Crop Grower,	Dutterer & Esaley, Hanover, Pa.,
1111		J. A. McBride, Craigsville,
CHICAGO FERTILIZER CO., CHICAGO, ILL.		
747	Bone, Blood and Potash,	Jno. A. Replogie, Curry,
CLARK'S COVE FERTILIZER CO., NEW YORK.		
1935	Defiance Complete Manure,	A. Cameron Bobb, Paxinos, Pa.,
E. FRANK COE & CO., NEW YORK CITY.		
1114	Knickerbocker,	Wm. Snyder, Cowansville, Pa.,
917	{ No. 1 Pennsylvania Grain Special,	D. E. Arbogast, Dry Valley, Pa.,
1220		Heffner & Luckenbill, Friedensburg, Pa.
HENRY COPE & CO., LINCOLN UNIVERSITY, PA.		
1071	Pure Bone Phosphate,	Henry Cope & Co., Oxford, Pa.,
J. A. CRANSTON CO., NEWPORT, DEL.		
1362	Pennsylvania Superior Phosphate,	Richards & Owens, Fairville, Pa.,
984	{ W. B., Raw Bone Super Phosphate,	H. F. Dugan, Clarkstown, Pa.,
1261		Richards & Owens, Fairville, Pa.,
CUMBERLAND BONE PHOSPHATE CO., PORTLAND, ME.		
926	Seeding Down Fertilizer,	J. J. Zimmerman, Stoystown, Pa.,

For explanation of these tables see page 27. †Composite sample.

LIZERS—Continued.

Moisture in 100 pounds.	Phosphoric Acid in 100 Pounds.								Potash in 100 Pounds. (Water Soluble.)				Nitrogen in 100 Pounds.		Computed commercial value of 2,000 pounds at Department rating. (See p.)	Selling price of 2,000 pounds at the point of selection.	Sample number.
	Soluble in water.	Reverted.	Insoluble.	Total.		Available.		Present as nitrate.	Present as sulphate.	Total.		Found.	Guaranteed.				
				Found.	Guaranteed.	Found.	Guaranteed.			Found.	Guaranteed.						
9.73	5.59	3.48	1.40	10.47	10.00	9.07	8.00	3.03	.....	2.02	3.00	1.21	1.02	22.03	22.00	802	1094
4.96	4.48	4.79	3.53	12.79	10.00	9.27	8.00	1.66*	1.87	3.47	3.00	2.82	2.05	20.93	21.00	1092	
8.87	6.30	3.44	.56	10.30	.....	9.74	.....	3.02	.....	3.02	.....	1.54	.....	24.79	24.00	838	
8.71	6.23	3.21	.70	10.14	.....	9.44	.....	1.31	.....	1.31	.....	1.22	.....	21.49	20.00	840	
6.80	5.41	4.24	1.10	10.75	11.00	9.65	9.00	2.33	.....	2.32	2.00	.75*	.82	21.15	23.00	839	
11.64	5.11	4.23	1.33	10.67*	11.00	9.34	9.00	2.32	.....	2.32	2.00	.72*	.83	20.70	24.00	968	
10.48	5.61	3.37	1.51	10.49	10.00	8.98	8.00	2.11	.....	2.11	1.00	1.15	.82	21.94	19.00	846	
															24.00	1111	
8.04	2.21	4.13	5.53	11.86	10.00	6.33*	9.00	1.77	.....	1.77*	2.00	1.36	1.24	20.95	24.50	747	
5.12	2.12	7.09	1.88	11.09	9.00	9.21	7.00	1.44	.....	1.44	1.00	.91	.82	20.32	21.00	1635	
9.78	7.18	2.83	2.13	12.14	9.00	10.01	8.00	1.06	1.13	2.18*	2.25	1.44	1.24	26.43	25.00	1114	
8.25	4.53	3.57	2.98	11.03	.....	8.10	.....	3.30	.....	3.30	.....	1.22	.....	23.54	24.00	917	
															19.00	1220	
8.03	2.65	5.84	2.86	11.35	9.00	8.49	8.00	2.24	.....	2.24	2.00	1.92	1.65	24.63	26.00	1071	
10.69	5.04	2.78	2.26	10.08	10.00	7.82*	8.00	3.63	.....	3.63	2.00	1.06	1.63	22.20	20.00	1362	
11.78	6.03	3.16	2.12	11.31	11.00	9.19	9.00	2.45	.....	2.45	2.00	1.63*	1.65	24.72	25.00	984	
															23.00	1361	
9.80	4.04	3.27	1.64	8.95*	9.00	7.31	7.00	1.38	.....	1.38	1.00	.99	.82	18.72	21.00	926	

*Constituent falls below guarantee.

COMPLETE FERTI

Sample number.	Manufacturer and Brand.	From Whom Sample Was Taken.
	DETRICK FERTILIZER AND CHEM CO., BALTI-MORE, MD.	
694	Paragon Ammoniated Phosphate and Potash,	E. M. Swope, Petersburg, Pa.,
997	Paragon Bone Phosphate and Potash,	L. M. Lenis, Lindsey, Pa.,
1212	Royal Crop Grower,	Francis Balliet, Andreas,
	JOS. R. GAWTHROP, KENNETT SQUARE, PA.	
1356	Champion Bone Fertilizer for Wheat and Grass,	Septimus Nevin, Landenburg, Pa.,
1358	Complete Ammoniated Bone Phosphate,	Jos. R. Gawthrop, Kennett,
	CHAS. V. GEIGER, GEIGER'S MILLS, PA.	
988	"Try Me" Brand No. 1,	A. L. Kindt, Allenwood, Pa.,
1170	†Try Me Brand No. 7,	Chas. V. Geiger, Hamburg, Pa.,
1337		Chas. V. Geiger, Joanna, Pa.,
	GREAT EASTERN FERTILIZER CO., RUTLAND, VT.	
924	General Fertilizer,	Jos. Miller, Friends' Pa. (P. O. Bills, Pa.),
1088	†Northern Corn Special,	Jas. Cooper, Montrose, Pa.,
1091		Geo. Frint, W. Bridgewater, Pa.,
	GRIFFITH & BOYD, BALTIMORE, MD.	
1024	Special Guano,	A. B. Harnish, Mechanicsburg, Pa.,
	W. S. HASTINGS & SON, ATGLEN, PA.	
1064	Octoraro No. 1 Bone Phosphate,	W. S. Hastings & Son, Atglen, Pa.,
	S. M. HESS & BRO., PHILADELPHIA, PA.	
1179	†Keystone No. 1 Bone Phosphate,	L. H. Oswald, Lynport, Pa.,
893		Martin L. Pfaff, Craigsville, Pa.,
1186		Jas. Leebo, Carlisle, Pa.,
	M. P. HUBBARD & CO., BALTIMORE, MD.	
778	Celebrated Dissolved Bone,	C. A. Lerew, Dillsburg, Pa.,
979	Hubbard's Bone Phosphate,	M. Gilles, Pennsdale, Pa.,
	HUBBARD & CO., BALTIMORE, MD.	
816	†Columbia Gem Phosphate,	D. W. Sunday, Marysville, Pa.,
801		Lewis Arnold, Pfoutz Valley, Pa.,
975		M. Gilles, Pennsdale, Pa.,

Explanation of these tables see page 27. †Composite sample.

LIZERS—Continued.

Moisture in 100 pounds.	Phosphoric Acid in 100 Pounds.								Potash in 100 Pounds. (Water Soluble.)				Nitrogen in 100 Pounds.				Computed commercial value of 2,000 pounds at Department rating. (See p.)	Selling price of 2,000 pounds at the point of selection.	Sample number.
	Soluble in water.	Reverted.	Insoluble.	Total.		Available.		Present as muriate.	Present as sulphate.	Total.		Found.	Guaranteed.	Found.	Guaranteed.				
				Found.	Guaranteed.	Found.	Guaranteed.			Found.	Guaranteed.								
7.50	3.27	5.27	1.48	10.02	9.00	8.54	7.00	1.19	.....	1.19	1.00	1.03	.82	19.83	21.00	694		
8.80	4.30	4.00	2.77	11.07	9.00	8.30	7.00	1.10	.....	1.10	1.00	.96	.82	19.87	18.00	997		
13.91	5.60	2.95	2.44	10.90	9.00	8.55	8.00	2.45	.....	2.45	2.00	1.53*	1.65	23.76	22.00	1212		
8.25	3.75	3.69	9.29	16.73	13.00	7.44	8.00	2.16	.....	2.16	1.00	2.55	1.65	29.05	26.00	1356		
9.15	5.27	2.52	3.46	11.25	8.00	7.79	6.00	2.53	.....	2.53	1.25	1.68	1.03	24.04	25.00	1358		
8.86	1.66	5.24	5.63	12.52	.....	6.90*	8.00	1.17	.....	1.17*	6.00	.40*	1.63	17.78	24.00	988	
11.18	3.29	5.83	4.79	13.90	.....	9.11	8.00	1.05	.....	1.05*	6.00	.33*	1.63	14.12	.....	1170
														20.00	1237				
10.35	5.13	3.16	1.13	9.41	9.00	8.29	8.00	4.43	.....	4.43	4.00	.82	.82	22.03	20.50	924		
8.36	5.73	3.14	2.73	11.60	9.00	8.87	8.00	2.71	.....	2.71	2.00	2.57	2.47	23.26	26.00	1068		
														25.00	1091				
6.44	6.39	4.23	2.82	13.49	10.00	10.67	9.00	4.57	.....	4.37*	5.00	1.73*	1.85	23.02	25.00	1024		
7.17	6.12	2.99	3.00	12.11	.....	9.11	8.00	.93	1.89	2.92*	8.00	1.53*	1.65	25.33	22.00	1064		
6.63	5.82	3.47	.77	10.06	9.00	9.29	8.00	1.85	.....	1.95	1.00	1.15	.82	21.68	24.00	1179		
														23.00	893				
														22.00	1193				
9.57	6.71	2.50	1.08	10.29*	10.50	9.21	9.00	1.85	.....	1.85	.....	2.07	2.06	25.18	22.00	778	
8.85	8.06	2.87	1.61	12.53	10.50	10.92	9.00	2.55	.....	2.55	.....	2.06	2.06	28.20	25.00	979	
10.11	4.53	4.50	2.11	11.14	.....	9.03	8.00	1.53	.....	1.53	1.50	.60	.41	19.54	12.70	816	
														19.00	801				
														18.00	975				

*Constituent falls below guarantee.

Sample number.	Manufacturer and Brand.	From Whom Sample Was Taken.
1054	Oriental Phosphate for Wheat and Grass, INTERNATIONAL SEED CO., ROCHESTER, N. Y.	H. B. Lowe, Orangeville, Pa.,
1241	Electric Guano, T. S. KENDERDINE & SONS, NEWTOWN, PA.	Daniel Hammond, Black Hawk, Pa.,
1379	Ammoniated Phosphate,	Hobensack Bros., Ivyland, Pa.,
1382	Potato Phosphate, KEYSTONE CHEMICAL FERTILIZER CO., PHILA- DELPHIA, PA.	Hobensack Bros., Ivyland, Pa.,
864	Keystone Harvest Queen Phosphate, THE LACKAWANNA FERTILIZER AND CHEMI- CAL CO., MOOSIC, PA.	L. F. McCallister, Quarryville,
1093	} } 1208 } †Moosic Phosphate, 733 } 1339 }	Samuel Shook, E. Dimock, Pa., }
		J. C. Brubaker, N. E. Brubaker's, Pa., . }
		Sylvester Reynolds, Salix, Pa., }
		R. H. Angstadt, Lyons, Pa., }
	LANCASTER CHEMICAL CO., LANCASTER, PA.	
1209	Dewey Brand for Tobacco and Spring Crops,	C. B. Shelly, Lancaster, Pa.,
1207	Flag Brand Super Phosphate,	M. J. Berkhold, Lancaster, Pa.,
1206	Pure Dissolved Animal Bone and Potash, LAZARETTO GUANO CO., BALTIMORE, MD.	Martin E. Rutt, Lancaster, Pa.,
848	} } 1010 } †Bone Compound, 1011 }	J. H. Cashman, Hanover, Pa., }
		R. A. Lents, Red Lion, Pa., }
	Excelsior A. A. A. Fertilizer, A. B. LETHERBURY, CHESTER, PA.	R. A. Lents, Red Lion, Pa.,
1087	The Chester Brand Bone Phosphate, LISTER'S AGR'L & CHEM. WKS., NEWARK, N. J.	A. B. Letherbury, Chester, Pa.,
1224	Crop Producer, MAPES FORMULA AND PERUVIAN GUANO CO., NEW YORK.	M. I. Greenwalt, Orwigsburg, Pa.,
1227	Fruit and Vine Manure,	A. F. Kimmel, Orwigsburg, Pa.,
1229	Grass and Grain Spring Top Dressing,	A. F. Kimmel, Orwigsburg, Pa.,
1232	Root and Fruit,	A. F. Kimmel, Orwigsburg, Pa.,

For explanation of these tables see page 27. †Composite sample.

LIZERS—Continued.

Moisture in 100 pounds.	Phosphoric Acid in 100 Pounds.								Potash in 100 Pounds. (Water Soluble.)				Nitrogen in 100 Pounds.		Computed commercial value of 2,000 pounds at Department rating. (See p.)	Selling price of 2,000 pounds at the point of selection.	Sample number.
	Soluble in water.	Reverted.	Insoluble.	Total.		Available.		Present as muriate.	Present as sulphate.	Total.		Found.	Guaranteed.				
				Found.	Guaranteed.	Found.	Guaranteed.			Found.	Guaranteed.						
10.13	3.97	4.36	3.63	11.36	.....	8.33*	9.00	2.03	.....	2.08	1.50	.92	.82	20.80	18.00	1064
10.30	5.96	2.72	1.73	10.40	10.00	8.68	8.00	1.87	.19	2.06	2.00	.76*	.92	20.25	21.00	1241	
9.31	8.35	3.42	.96	12.73	12.00	11.77	10.00	2.80	.....	2.30	2.00	1.34	1.24	25.99	25.00	1373
10.25	7.13	3.23	.59	11.30*	12.00	10.41	8.00	3.42	.....	3.12	10.00	1.18*	1.65	29.96	29.00	1382
10.21	4.75	5.65	1.33	11.73	.....	10.40	10.00	3.78	.....	3.78	4.00	.82	.82	23.71	25.00	861
6.22	3.53	3.67	1.53	8.72*	9.00	7.19	7.00	.66	.39	1.05*	1.50	1.06*	1.34	13.39	23.00	1093	
															22.00	1208	
															24.00	732	
															20.00	1339	
8.43	3.40	5.23	1.34	9.92	9.00	8.68	8.00	2.33	.94	3.97	4.00	1.25	1.24	23.52	23.00	1209	
10.24	3.43	5.49	1.95	10.87	9.00	8.92	8.00	2.14	.....	2.14	2.00	1.21*	1.34	22.03	21.00	1207
7.32	3.31	5.23	1.83	10.87*	11.00	9.04*	10.00	2.33	2.33	5.23	5.00	1.49*	1.65	26.67	28.00	1294	
8.17	6.75	3.23	1.34	11.32	10.00	9.98	9.00	3.05	.....	3.05	3.00	1.12	1.08	23.80	20.00	843
															21.00	1010	
6.60	2.73	6.52	1.32	11.07	8.00	9.25	7.00	1.23	.....	1.23	1.00	.86	.82	20.08	18.00	1011
10.86	5.23	2.09	2.02	9.40*	9.50	7.38*	8.00	1.20	.74	1.94	1.50	1.25	1.24	20.77	23.00	1097	
3.83	1.62	5.16	3.63	10.41	8.00	6.73*	7.00	.....	1.10	1.10	1.00	.77	.82	20.16	17.20	1234
7.84	2.69	3.54	2.19	8.42	.....	6.23	5.00	1.47	10.07	11.54	10.00	1.99	1.65	33.55	39.00	1237
9.51	4.71	1.40	.60	6.71	.....	6.11	5.00	7.93	.....	7.93	7.00	4.83	4.94	38.36	38.00	1329
14.31	7.43	2.34	.53	10.29	.....	9.76	8.00	8.86	.....	8.86*	9.00	.95	.92	28.53	30.00	1233

*Constituent falls below guarantee.

COMPLETE FERTI

Sample number.	Manufacturer and Brand.	From Whom Sample Was Taken.
MARYLAND FERTILIZER AND MANUFACTURING CO., BALTIMORE, MD.		
979	O. K. Ammoniated Super Phosphate,	J. G. Simpson, Huntingdon, Pa.,
McCALMONT & CO., BELLEFONTE, PA.		
698	\$25.00 Champion Ammoniated Bone Super Phosphate,	J. S. McCalmont, Bellefonte, Pa.,
MILLER FERTILIZER CO., BALTIMORE, MD.		
1201	Ammoniated Dissolved Bone,	Martin & Muth, Littitz, Pa.,
1188	} †Harvest Queen,	} S. N. Bailey & Bros., Dillsburg, Pa., ... }
1202		
1189	Standard Phosphate,	Martin & Muth, Littitz, Pa.,
MORO PHILLIPS FERTILIZER CO., PHILA., PA.		
1211	} †C. & G. Complete Fertilizer,	} Nathan D. Hunsicker, Andreas, Pa., ... }
897		
1225	} Pure Phosine,	} J. H. Woerber, Oak Hall, Pa.,
1215		
1217	Special Fertilizer,	J. W. Drehr, Orwigsburg,
1178	} †Standard Guano,	} Nathan D. Hunsicker, Nantz, Pa.,
1216		
WM. C. NEWPORT CO., WILLOW GROVE, PA.		
1283	Ammoniated Bone Phosphate,	Nathan D. Hunsicker, Nantz, Pa.,
PATAPSCO GUANO CO., BALTIMORE, MD.		
813	} †Fish Guano,	} Charles Henry, Lynport, Pa.,
1150		
866	Grange Mixture,	Nathan D. Hunsicker, Mantz, Pa.,
973	Special Wheat Compound,	Charles Henry, Lynport, Pa.,
J. DOUGLASS PERKINS, COATESVILLE, PA.		
1075	} †Perkins' Celebrated Monarch H. G.,	} Nathan D. Hunsicker, Mantz, Pa., }
1195		
1076	Special Bone Manure,	Charles Henry, Lynport, Pa.,
PIEDMONT MT. AIRY GUANO CO., BALTIMORE, MD.		
727	Piedmont Pine Raw Bone Mixture,	Nathan D. Hunsicker, Mantz, Pa., }
J. M. HANSBERGER & SONS, JOHNSTOWN, PA.		

For explanation of these tables see page 27. †Composite sample.

LIZERS—Continued.

Moisture in 100 pounds.	Phosphoric Acid in 100 Pounds.								Potash in 100 Pounds. (Water Soluble.)				Nitrogen in 100 Pounds.		Computed commercial value of 2,000 pounds at Department rating. (See p. .)	Selling price of 2,000 pounds at the point of selection.	Sample number.
	Soluble in water.	Reverted.	Insoluble.	Total.		Available.		Present as muriate.	Present as sulphate.	Total.		Found.	Guaranteed.				
				Found.	Guaranteed.	Found.	Guaranteed.			Found.	Guaranteed.						
10.51	6.60	2.22	.88	9.70	9.00	8.82	8.00	2.39	.....	2.39	2.00	.97	.82	21.12	22.00	679
9.69	7.24	2.26	2.00	11.50	11.00	9.50	9.00	2.13	.....	2.13	2.00	1.66	1.65	24.84	25.00	693
9.69	6.09	2.25	1.34	9.68*	10.00	8.34	8.00	2.21	.....	2.21	2.00	1.68	1.65	23.37	23.00	1201
10.25	7.92	2.92	1.03	11.87	11.50	10.84	10.00	2.34	.....	2.34	2.25	1.01*	1.03	.....	24.00	1188
9.41	6.45	2.01	1.31	9.77*	10.00	8.46	8.00	3.00	.....	3.00	3.00	2.48	2.47	27.28	28.00	1189
10.75	5.48	2.87	1.54	9.89*	10.00	8.35	8.00	2.20	.....	2.20	2.00	.82	.82	20.05	20.00	1211
5.63	2.07	8.10	1.61	11.78	10.00	10.17	8.00	2.55	.....	2.55*	3.00	1.61*	1.65	24.99	23.00	1215
11.00	4.99	3.07	2.33	10.44	10.00	8.06	8.00	3.23	.....	3.23	3.00	1.96*	2.06	25.42	24.00	1217
9.96	4.27	3.69	2.54	10.50	9.00	7.96*	8.00	4.05	.....	4.05	4.00	.83	.82	22.02	22.00	1178
10.42	5.17	3.83	2.33	11.38	9.00	9.00	7.00	2.05	.....	2.05	2.00	1.72	1.65	24.31	25.00	1283
9.28	4.76	2.96	2.00	9.72	7.00	7.72	6.00	2.48	.....	2.48	2.00	1.66	1.65	22.95	20.00	813
10.32	7.02	2.24	1.69	11.15*	12.50	9.26*	10.00	3.33	.....	2.33	2.00	1.65	1.65	24.69	22.00	866
8.47	5.40	6.83	1.30	13.43*	14.00	12.23	9.00	2.69	.....	2.69	2.50	1.86	1.95	28.51	24.00	973
11.36	6.91	3.49	.45	10.85*	12.36	10.40*	11.64	7.07	.....	7.07	6.68	1.29	.86	23.70	27.00	1075
8.18	5.70	3.42	1.00	10.12	9.00	9.12	8.00	1.02	.....	1.02	1.00	1.02	.82	20.13	23.00	1195
8.21	2.73	5.75	3.48	11.96	.....	8.48	8.00	1.35	.....	1.85	1.50	1.07	1.03	21.37	24.00	737

*Constituent falls below guarantee.

COMPLETE FERTI

Sample number.	Manufacturer and Brand.	From Whom Sample Was Taken.
	PITTSBURG PROVISION CO., PITTSBURG, PA.	
1240	Corn and Potato Fertilizer,	Wm. McClinton, Black Hawk, Pa.,
751	Tobacco Special, "Pine Bone with Potash,"	E. H. Curtis, Knox, Pa. (P. O. Monroe),
	R. H. POLLOCK, BALTIMORE, MD.	
1008	{ †Ammoniated Bone,	{ Elias Gable, Red Lion, Pa.,
1287	{	{ B. F. Shearer, Doylestown, Pa.,
1184	{	{ Jno. A. Lindsey, Carlisle,
810	{ †Owl Brand Guano,	{ W. H. Shearer, New Bloomfield, Pa., ..
1286	{	{ B. F. Shearer, Doylestown, Pa.,
811	{	{ W. H. Shearer, New Bloomfield, Pa., ...
819	{ †Special Wheat Grower,	{ Jno. Nisley, Middletown, Pa.,
	THE QUINNIPLAC CO., NEW YORK.	
911	Corn Manure,	J. W. Painter & Co., Red Top, Pa.,
	RAMSBURG FERTILIZER CO., FREDERICK, MD.	
789	Old Virginia,	S. H. Duncan, Abbottstown, Pa.,
	RASIN-MONUMENT CO., BALTIMORE, MD.	
1248	Rasin's Ammoniated Alkaline Phosphate,	Wm. Davis, Jr., Greensboro, Pa.,
1247	Rasin's Empire Guano,	Wm. Davis, Jr., Greensboro, Pa.,
	JOHN S. REESE & CO., BALTIMORE, MD.	
1005	{ †Half and Half,	{ Nathan G. Herbst, Red Lion, Pa.,
1296	{	{ Ball & Rhoads, Media, Pa.,
	ISAAC ROBINSON, BALTIMORE, MD.	
1043	{ †Fish, Rock and Potash,	{ J. R. Shaffer, S. Danville, Pa.,
1061	{	{ Geo. Garnhart, Dewart, Pa.,
1042	Peerless Phosphate,	J. R. Shaffer, S. Danville, Pa.,
1044	Pennsylvania Special Mixture,	J. R. Shaffer, S. Danville, Pa.,
1045	Special Wheat and Grass Phosphate,	J. R. Shaffer, S. Danville, Pa.,
	THE RUSSELL AGR'L CHEM. CO., NEWARK, N. J.	
1165	Russell's Harvest Queen Phosphate,	M. C. Dietrich, Kempton, Pa.,
	SCHAAL-SHELDON FERTILIZER CO., ERIE, PA.	
771	Grass, Grain and Potato,	W. H. Wadding, Dayton, Pa.,

For explanation of these tables see page 37. †Composite sample.

LIZERS—Continued.

Moisture in 100 pounds.	Phosphoric Acid in 100 Pounds.								Potash in 100 Pounds. (Water Soluble.)				Nitrogen in 100 Pounds.		Computed commercial value of 2,000 pounds at Department rating. (See p.)	Selling price of 2,000 pounds at the point of selection.	Sample number.
	Soluble in water.	Reverted.	Insoluble.	Total.		Available.		Present as muriate.	Present as sulphate.	Total.		Found.	Guaranteed.				
				Found.	Guaranteed.	Found.	Guaranteed.			Found.	Guaranteed.						
3.96	1.14	4.49	7.21	12.84	11.00	5.63	9.00	.40	2.82	2.92*	3.00	1.96	1.65	24.76	25.00	1240	
4.28	3.06	3.67	9.34	16.07	14.00	6.73*	12.00	.....	2.86	2.96*	3.00	3.14*	2.47	31.64	.....	751
11.92	5.59	2.94	2.08	10.61	10.00	8.53*	9.00	2.17	.....	2.17	3.00	1.68	1.65	23.83	22.00	1008
															25.00	1287	
															20.00	1184	
9.23	4.45	3.20	1.11	8.76	8.00	7.85	7.00	2.12	.....	2.12	1.50	.50	.41	17.73	17.25	810
															21.00	1286	
11.42	5.55	4.07	1.60	11.22	10.00	9.62	9.00	2.19	.....	2.19	3.00	.78*	.82	21.44	19.20	811
															19.00	819	
10.64	5.06	2.80	2.87	11.25	9.00	8.88	8.00	1.51	.....	1.51	1.50	2.07	2.06	24.92	22.00	911
12.49	6.30	4.92	3.03	14.30	11.00	11.22	9.00	1.63	.....	1.63*	3.00	1.39	1.24	26.63	20.00	789
12.46	6.23	2.64	.69	10.26	9.00	9.57	8.00	2.71	.....	2.71	1.00	1.40*	1.65	24.93	22.00	1245
12.68	6.91	2.75	.77	10.43	9.50	9.66	8.00	2.12	.....	2.12	3.00	1.36*	1.65	23.22	24.00	1247
9.93	4.18	3.93	1.10	9.21	9.00	8.11	7.00	1.32	.....	1.32	1.00	1.07	.82	19.42	12.00	1006
															22.00	1298	
4.07	.82	5.55	2.65	8.42	.....	6.37	5.00	.88	.....	.88	.50	.76	.21	16.06	12.78	1043
															14.00	1061	
7.83	5.90	2.47	1.32	10.70	10.00	9.37	8.00	1.92	.....	1.92	1.50	.76	.42	20.63	15.58	1042
8.00	5.41	3.17	1.55	10.43	8.50	8.58	7.00	4.59	.....	4.59	5.00	1.52*	1.65	25.50	21.85	1044
9.22	6.19	3.17	1.28	10.64*	11.00	9.36	8.50	2.51	.....	2.51	2.00	1.61*	1.65	24.38	20.19	1045
11.24	5.51	3.95	2.35	11.81	.....	9.46*	9.50	2.02	.....	2.02	3.00	1.04*	1.24	22.85	22.00	1166
9.80	6.36	2.91	3.21	12.98	9.00	9.77	8.00	2.08	.....	3.08	4.00	1.57	1.35	26.28	24.00	771

*Constituent falls below guarantee.

COMPLETE FERTI

Sample number.	Manufacturer and Brand.	From Whom Sample Was Taken.
	THE SCIENTIFIC FERTILIZER CO., PITTSBURG, PA.	
1235	Potato Fertilizer,	James Storer, Holt, Pa.,
974	Scientific Bone, Meat and Potash Fertilizer,	H. H. Sundry, Warrensville, Pa.,
	SCOTT FERTILIZER CO., ELKTON, MD.	
1294	Farmers' Union Phosphate,	Ed. Worrall, Media, Pa.,
865	Standard Phosphate,	S. Book & Bro., Quarryville, Pa.,
	SHARPLESS & CARPENTER, PHILADELPHIA, PA.	
798	No. 1 Phosphate,	A. H. Ulah, Millerstown, Pa.,
1142	} †Dissolved Bone Phosphate for Potatoes and Gen eral Use.	Geo. K. Linderman, Geigertown, Pa., ..
1147		Geo. W. Rabenhold, Hamburg, Pa.,
	SHENANDOAH FERTILIZER CO., SHENANDOAH, PA.	
1050	Supplee's Grain and Grass Producer,	H. G. Supplee, Bloomsburg, Pa.,
	M. S. SHOEMAKER & CO., PHILADELPHIA, PA.	
1351	Good Enough Super Phosphate,	David Heistand, Kimberton, Pa.,
1316	Swift Sure Guano for Fall Trade,	Byers & Sems, Honeybrook, Pa.,
	E. A. SLAGLE, PAXINOS, PA.	
1037	Xtra Bone Phosphate,	E. A. Slagle, Paxinos, Pa.,
	STANDARD FERTILIZER CO., NEW YORK.	
1108	Standard Guano,	E. S. Campbell, New Albany, Pa.,
	SUSQUEHANNA FERTILIZER CO., BALTIMORE, MD.	
1069	Ammoniated Bone Phosphate,	Geo. B. Passmore Sons, Oxford, Pa.,
1067	Pure Bone Phosphate,	Geo. B. Passmore Sons, Oxford, Pa.,
	SWIFT & CO., CHICAGO, ILLINOIS.	
1245	} †Swift's Pure Super Phosphate,	A. Pratschle, New Castle, Pa.,
1269		P. H. Saxman, Latrobe, Pa.,
1124		Fred. Zehner, Zellenople,
1234		A. Gladdis & Co., Uniontown,
	TAYLOR PROVISION CO., TRENTON, N. J.	
1375	Ammoniated Dissolved Bone and Potash,	Isaac W. Holcombe, New Hope, Pa.,

For explanation of these tables see page 27. †Composite sample.

LIZERS—Continued.

Moisture in 100 pounds.	Phosphoric Acid in 100 Pounds.								Potash in 100 Pounds. (Water Soluble.)				Nitrogen in 100 Pounds.		Computed commercial value of 2,000 pounds at Department rating. (See p. .)	Selling price of 2,000 pounds at the point of selection.	Sample number.
	Soluble in water.	Reverted.	Insoluble.	Total.		Available.		Present as muriate.	Present as sulphate.	Total.		Found.	Guaranteed.				
				Found.	Guaranteed.	Found.	Guaranteed.			Found.	Guaranteed.						
5.80	5.58	2.79	3.59	11.96	10.50	8.37*	8.50	.....	6.29	6.29	6.00	2.11*	2.25	21.18	25.00	1235
6.03	5.99	2.44	3.41	11.84	9.50	8.43	7.25	.....	3.47	5.47	8.00	2.06*	3.09	33.66	30.00	974
9.34	4.54	5.01	4.29	13.84	.....	9.55	.....	5.72	.....	5.72	.....	1.64	.....	29.29	.....	1294
11.15	8.24	3.15	1.45	12.87	10.00	11.39	8.00	3.18	.....	3.18	2.00	1.29	1.24	26.50	22.00	865
9.03	4.69	4.08	2.11	10.88	10.00	8.77	8.00	2.23	.....	2.23	2.00	1.64*	1.65	23.91	24.00	798
7.44	3.80	4.65	2.87	11.12	10.00	8.25	8.00	5.84	.....	5.84*	6.00	2.00*	2.06	28.58	27.00	1142
															28.00	1147	
8.21	3.71	4.13	2.33	10.21	.....	7.83	.....	2.98	.....	2.98	.....	.59	.....	19.71	20.00	1050
11.13	8.83	3.66	3.86	16.35	12.00	12.40	8.00	3.14	.....	2.14	2.00	1.27*	1.65	27.67	27.00	1251
9.22	3.80	4.85	5.07	13.72	.....	8.05	8.00	4.90	.87	5.77	5.00	1.90	1.65	29.72	25.00	1316
9.68	6.66	2.80	.95	10.41	.....	9.46	8.00	3.39	.....	3.39	2.00	.72*	.82	21.93	20.00	1087
10.26	2.76	4.99	3.45	11.20	10.00	7.75*	8.00	2.31	.....	2.31	2.00	1.11	1.02	21.20	25.00	1108
8.55	2.35	4.70	6.25	13.30	10.00	7.05*	8.00	2.33	.....	2.38	2.00	1.51*	1.65	23.33	22.00	1069
8.63	6.55	4.55	4.96	16.06	10.00	11.10	8.00	.....	2.43	2.43	2.00	1.80	1.65	29.19	26.00	1067
5.05	5.91	3.83	2.95	12.69	12.00	9.74	8.00	.....	2.04	2.04	2.00	2.29*	2.47	28.03	24.00	1245
															26.00	1269	
															24.00	1124	
															.....	1284
9.70	5.06	3.79	3.69	12.54	10.00	8.85	8.00	2.27	.....	2.27*	2.50	1.16	.59	22.92	24.00	1375

*Constituent falls below guarantee.

COMPLETE FERTI

Sample number.	Manufacturer and Brand.	From Whom Sample Was Taken.
1376	Complete Fertilizer for Wheat and Grass,	Isaac W. Holcombe, New Hope, Pa.,
	J. M. TEMPLIN, HONEYBROOK, PA.	
1143	Atlas Brand, No. 4,	J. M. Templin, Reading, Pa.,
1141	H. G. Potash Manure,	J. M. Templin, Joanna, Pa.,
	I. P. THOMAS & SON CO., PHILADELPHIA, PA.	
1313	Champion Bone Phosphate,	Byers & Lenis, Honeybrook, Pa.,
1308	Farmer's Choice Bone Phosphate,	Byers & Lenis, Honeybrook, Pa.,
1311	Tip Top Raw Bone Super Phosphate,	Byers & Lenis, Honeybrook, Pa.,
	TUSCARORA FERTILIZER CO., PORT ROYAL, PA.	
688	} †Pennsylvania Standard Phosphate,	W. S. Henderson, Alexander, Pa.,
995		Grier & Osterhout, Punxsutawney,
	I. J. TUSTIN, PHOENIXVILLE, PA.	
1344	Pickering Valley H. G.,	I. J. Tustin, Phoenixville, Pa.,
1345	Pickering Valley Special,	I. J. Tustin, Phoenixville, Pa.,
1346	Pickering Valley Special for Potatoes,	I. J. Tustin, Phoenixville, Pa.,
	J. E. TYGERT, & CO., PHILADELPHIA, PA.	
1335	Golden Harvest,	Wm. L. Fehr, Rock, Pa.,
	TYGERT-ALLEN FERTILIZER CO., PHILA., PA.	
1110	Star Bone,	J. L. Ward, Towanda, Pa.,
1341	Walton & Whann Co's Reliance Amm. Super Phos.,	L. W. Geiger, Joanna, Pa.,
	JACOB ULMER, POTTSVILLE, PA.	
1213	Ulmer's Blood, Bone & Meat Super Phosphate, ..	Moses Zellner, Andreas, Pa.,
	WALKER, STRATMAN & CO., PITTSBURG, PA.	
1131	} †Four Fold,	John Eisenbrown, Knob, Pa.,
871		W. J. Acorn, Echo, Pa. (P. O. Muff, Pa.).
1289		Hawkins & Ulery, Frederickstown, Pa., .
1112	Potato Special,	Chas. Redd, Cowansville, Pa.,
	F. K. WALT & CO., WAYNESBURG JCT., PA.	
1307	Sure Growth Phosphate,	O. A. Boyle, Waynesburg, Pa. (P. O. Coatesville).
1078	XX Flesh and Animal Bone Phosphate,	Geo. B. Pyle, Coatesville (P. O. Cain, Pa.).

For explanation of these tables see page 27. †Composite sample.

LIZERS—Continued.

Moisture in 100 pounds.	Phosphoric Acid in 100 Pounds.								Potash in 100 Pounds. (Water Soluble.)				Nitrogen in 100 Pounds.				Computed commercial value of 2,000 pounds at Department rating. (See p.)	Selling price of 2,000 pounds at the point of selection.	Sample number.
	Soluble in water.	Reverted.	Insoluble.	Total.		Available.		Present as muriate.	Present as sulphate.	Total.		Found.	Guaranteed.	Found.	Guaranteed.				
				Found.	Guaranteed.	Found.	Guaranteed.			Found.	Guaranteed.								
9.80	6.03	2.82	3.50	12.35*	13.00	8.85*	10.00	3.69	.....	3.00	2.50	2.34*	3.00	28.28	29.00	1376		
6.36	6.38	3.66	3.95	13.99	11.00	10.04	10.00	.....	4.01	4.01	4.00	1.54*	1.65	28.50	26.00	1143		
7.96	7.24	3.16	2.81	13.21	12.00	10.40*	11.00	.....	6.70	6.70*	8.00	.89	.82	28.77	27.00	1141		
9.72	6.33	3.44	1.93	11.70*	12.00	9.77*	10.00	2.30	.....	2.30*	4.00	1.27*	1.65	23.67	25.00	1313		
9.27	3.81	4.59	3.19	11.59	10.50	8.40*	9.50	2.38	.....	2.38	2.00	1.53*	1.65	23.68	28.00	1308		
12.19	5.38	3.77	3.64	12.29	12.00	9.65*	10.00	3.64	.....	3.04	2.75	2.21*	2.47	28.10	30.00	1311		
9.72	3.60	3.64	4.59	12.13	8.00	7.24	.....	2.11	.....	2.11	2.00	1.52*	1.65	22.75	23.00	688	
														24.00		995			
10.84	4.11	3.83	2.76	10.71*	11.00	7.95*	9.00	3.09	.....	3.09	3.00	1.57*	2.06	23.74	27.00	1344		
9.70	4.67	2.82	1.72	9.21	8.00	7.40	.....	1.49	.....	1.49	1.00	.91*	1.03	18.76	22.00	1346	
7.85	3.66	3.31	.79	7.70	8.00	6.97	.....	5.06	.....	5.06	5.00	1.27*	1.85	22.57	26.00	1316	
10.93	3.71	3.53	2.96	10.22	.55	7.24	.40	2.12	.....	2.12	.10	.52	.02	18.10	18.00	1335		
12.32	6.48	2.84	1.63	10.85	10.00	9.32	8.00	4.06	.....	4.06	3.00	2.13	2.06	28.20	26.00	1110		
13.07	5.59	2.93	2.45	10.97	.....	8.52	.....	5.10	.....	5.10	.....	1.51	.....	26.22	20.00	1311
11.08	7.46	1.69	3.09	12.24	11.50	9.15	9.00	.....	2.06	2.06	2.50	3.15	2.88	30.85	25.00	1313		
7.17	4.13	3.40	3.11	10.74	8.50	7.53	7.00	2.19	.....	2.19	2.00	1.40*	1.65	22.04	19.00	871		
														20.00		1289			
5.58	4.96	2.50	3.74	12.19	10.50	8.45*	8.50	.....	5.10	5.10	6.00	2.15*	2.27	30.04	.....	1112	
7.28	3.63	5.28	7.84	16.74	.....	8.90	.....	.13	.16	.29	.....	2.74	.....	28.78	.....	1307
7.05	1.53	4.10	7.94	13.57	9.00	5.63*	8.00	2.88	.....	2.88	2.00	.99*	1.65	21.13	22.00	1073		

*Constituent falls below guarantee.

COMPLETE FERTI

Sample number.	Manufacturer and Brand.	From Whom Sample Was Taken.
	M. E. WHEELER & CO., RUTLAND, VT.	
1026	} †H. G. Royal Wheat Grower,	Stoner, New Kingston, Pa.,
1278		G. W. Edwards, Dawson (P. O. Vanderblit, Pa.).
	WILLIAMS & CLARK FERTILIZER CO., NEW YORK.	
1138	} †Americus Royal Bone Phosphate,	Kachel & Griffiths, Knauerr's, Pa.,
1176		W. F. Krause, New Tripoli,
1280	Prolific Crop Producer,	C. B. Neiderheiser, Donegal, Pa.,
1102	Universal Ammoniated Dissolved Bone,	John McQueen, Ulster, Pa.,
	THE R. A. WOOLDRIDGE CO., BALTIMORE, MD.	
690	Buffalo Dissolved Bone Phosphate,	H. H. Black, Huntingdon, Pa.,
1027	Chieftain Phosphate,	Chas. Hetrick, New Kingston, Pa.,
733	Old Sledge Phosphate,	P. Shonk, Salix, Pa.,
	YORK CHEMICAL WORKS, YORK, PA.	
796	Prosperity Amm. Bone and Potash Phosphate,	Jessel L. Brodbeck, Hanover, Pa.,
	ZELL GUANO CO., BALTIMORE, MD.	
719	Ammoniated Bone Super Phosphate,	W. V. Shirk Oakland Mills, Pa.,
	HENRY S. ZOOK, ELVERSON, PA.	
1157	Pride of Chester Animal Bone Phosphate,	Henry S. Zook, Joanna, Pa.,

For explanation of these tables see page 27. †Composite sample.

LIQUORS—Continued.

Moisture in 100 pounds.	Phosphoric Acid in 100 Pounds.								Potash in 100 Pounds. (Water Soluble.)				Nitrogen in 100 Pounds.		Computed commercial value of 2,000 pounds at Department rating. (See p.)	Selling price of 2,000 pounds at the point of selection.	Sample number.
	Soluble in water.	Reverted.	Insoluble.	Total.		Available.		Present as muriate.	Present as sulphate.	Total.		Found.	Guaranteed.				
				Found.	Guaranteed.	Found.	Guaranteed.			Found.	Guaranteed.						
9.00	5.60	2.65	1.55	9.62	9.00	8.34	8.00	2.41	.....	2.41	2.00	.93°	1.35	50.84	18.00 17.00	1026 1278
12.76	5.40	2.89	2.12	10.41	9.00	8.29	8.00	2.12	.....	2.12	2.00	.92°	1.03	30.56	23.00 23.00	1123 1176
12.25	2.26	6.20	1.59	10.35	8.00	8.46	7.00	1.40	.....	1.40	1.00	1.04	.82	20.05	18.00	1280
12.25	6.13	3.34	1.71	11.18	9.00	9.47	8.00	2.26	.70	2.00	2.00	1.81	1.65	26.05	25.00	1102	
7.35	7.40	4.23	2.62	14.25	.....	11.63	10.00	.31	.....	.31	.....	1.06°	2.05	26.70	23.00	690
9.50	4.42	3.40	1.95	9.77°	10.50	7.82°	9.00	2.42	.....	2.42	2.00	1.68	1.65	23.06	19.50	1087
13.24	2.55	6.20	1.89	10.55	.....	8.75	8.00	1.37	.....	1.37	1.00	.90	.82	19.75	22.00	733
15.48	5.19	4.74	1.38	11.31°	12.00	9.93°	10.00	1.77	.....	1.77	2.00	.67°	.32	20.64	19.00	795
7.63	7.03	2.33	.87	10.73	10.00	9.86	8.00	2.04	.....	2.04	2.00	1.54°	1.65	24.21	20.50	719
9.29	5.82	3.31	3.31	12.44	9.00	9.13	8.00	3.17	.....	3.17°	6.00	1.67	1.65	25.93	23.75	1157

*Constituent falls below guarantee.

ROCK AND POTASH

Furnishing Phosphoric

Sample number.	Manufacturer and Brand.	From Whom Sample Was Taken.
1127	ALLIANCE FERTILIZER CO., ALLIANCE, OHIO. Farmer's Friend Phosphate,	M. C. Sinck, N. Sewickley, Pa.,
815	ARMOUR FERTILIZER CO., CHICAGO, ILL. †Phosphate and Potash,	J. L. Rizer & Son, Duncannon, Pa., . Crawford & Co., Greensboro, Pa.,
1230	BALTIMORE PULVERIZING CO., BALTIMORE, MD. P. C. U. Fertilizer No. 5,	I. G. Deringer, Esther, Pa.,
1239	WM. F. BAUGHMAN, RINELY, PA. Bone and Potash Phosphate,	A. E. March, Emigs Mills, Pa.,
1013	BOWKER FERTILIZER CO., BOSTON AND NEW YORK. Super Phosphate,	G. N. Englehart, Rand,
906	1082 1100 990 1146 1160 1120	Phillip Weaver, Millersburg, Macafee & Ingham, Ulster, Pa., Wrigley Hardware Co., Mahaffey, Pa., .. John W. Haws, Gibraltar, Pa., M. C. Dietrick, Kempton, Pa., J. G. and W. Campbell, Butler, Pa.,
	Wheat Grower, CLARK'S COVE FERTILIZER CO., NEW YORK CITY. Clark's Cove Triumph Bone and Potash,	Solomon Livingood, Joanna, Pa.,
1153	CUMBERLAND BONE & PHOSPHATE CO., PORTLAND, ME. Cumberland Dissolved Bone and Potash,	G. W. Esenwine, Salona, Pa.,
831	LOUIS F. DETRICK, BALTIMORE, MD. 769 900 683 1191	J. M. Reedy, Goheenville, Pa., Daniel Miller, Mifflinburg, Pa., W. T. Hoover, Port Matilda, Cook, Bents & Co., Dillsburg, Pa.,
	†Bone and Potash 16-4 Mixture,	

For explanation of these tables see page 27. †Composite sample.

FERTILIZERS.

Acid and Potash.

Moisture in 100 pounds.	Phosphoric Acid in 100 Pounds.								Potash in 100 Pounds.				Computed commercial value at Department rating. (See p.)	Selling price at the point of selection.	Sample number.
	Soluble in water.	Reverted.	Insoluble.	Total.		Available.		Present as muriate.	Present as sulphate.	Total.					
				Found.	Guaranteed.	Found.	Guaranteed.			Found.	Guaranteed.				
10.97	.63	7.85	1.58	10.06*	11.00	8.48*	10.00	.80	.21	1.01	1.00	9.20	16.00	1127	
9.85	6.24	6.23	1.50	14.12	11.50	12.62	9.50	2.00	.....	2.00	2.00	15.31	16.00 20.00	815 1290
9.81	2.25	7.44	1.70	11.39	.....	9.69	.....	2.25	.....	3.25	.....	14.42	13.00	1239
13.35	4.02	5.94	2.05	12.01	11.00	9.96*	10.00	2.04	.....	2.04	2.00	13.69	17.00	1013
2.40	5.05	5.63	3.13	13.81	.....	10.68	.....	1.12	.....	1.12	.....	13.68	16.00 15.00 17.00	906 1032 1100
11.20	6.30	4.53	2.97	13.79	11.00	10.82	10.00	1.23	.....	1.23	1.00	14.07	20.00 20.00 17.00	990 1146 1160
12.80	6.61	4.50	1.94	13.05	11.00	11.11	10.00	1.19	.....	1.19	1.00	13.73	26.00	1120
9.86	4.91	5.01	2.45	12.40	11.00	9.92*	10.00	1.95	.....	1.95*	2.00	13.83	15.00	1153
9.88	4.99	5.65	.78	11.42*	12.00	10.64	10.00	2.24	.....	2.24	2.00	13.96	17.50	831
9.04	6.22	5.06	2.55	13.86	12.50	11.31	11.00	2.03	.....	2.03	2.00	14.95	17.00 16.00 19.00 15.50	709 900 683 1191

*Constituent falls below Ordnance Sergeant.

ROCK AND POTASH

Sample number.	Manufacturer and Brand.	From Whom Sample Was Taken.
	GREAT EASTERN FERTILIZER CO., RUTLAND, VT.	
730	Soluble Bone and Potash Fertilizer,	Bumgardner & Gramblin,, Eltonburg. Pa.
	GRIFFITH & BOYD, BALTIMORE, MD.	
753	Special Grain Grower,	A. K. Straley, Dillsburg, Pa.,
	S. M. HESS & BRO., PHILADELPHIA, PA.	
809	} †Emperor Phosphate,	W. H. Sweger, New Bloomfield, Pa., ...
753		Samuel Beals, Knox, Pa.,
1181		W. D. Weaver, Andreas, Pa.,
1162	Soluble Bone and Potash,	S. M. Hess, Hamburg, Pa.,
	JARECKI CHEMICAL CO., SANDUSKY, OHIO.	
920	Dissolved Bone with Potash,	S. S. Mosholder, Brotherton, Pa.,
	LISTER'S AGRL. CHEM. WKS., NEWARK, N. J.	
1025	Animal Bone and Potash No. 2,	D. A. Ulrich, Mechanicsburg, Pa.,
	MARYLAND FERTILIZER AND MANUFACTURING CO., BALTIMORE, MD.	
710	} †Alkaline Bone,	John Shirey, Lewistown. Pa.,
1175		P. F. Oswald, New Tripoli, Pa.,
	G. OBER & SONS, BALTIMORE, MD.	
843	} †Dissolved Bone Phosphate and Potash,	R. B. Moors, Petersburg, Pa.,
850		G. W. Altland, Mount Top, Pa.,
	PATAPSCO GUANO CO., BALTIMORE, MD.	
723	} †H. G. Bone and Potash,	Phillip Harley, Mifflintown, Pa.,
915		H. H. Knauff, Lewisburg, Pa.,
1031		H. F. Zearing, Millersburg, Pa.,
792	} †Soluble Bone and Potash,	J. H. Hersh, New Oxford, Pa.,
1126		H. A. King, Brick Church, Pa.,
	J. DOUGLASS PERKINS, COATESVILLE, PA.	
1077	Globe Phosphate,	J. Douglass Perkins, Coatesville, Pa.,
	PIEDMONT MT. AIRY GUANO CO., BALTIMORE, MD.	
728	Farmer's H. G. Bone and Potash,	J. M. Harshberger & Sons, Johnstown, Pa.,

For explanation of these tables see page 27. †Composite sample

FERTILIZERS—Continued.

Moisture in 100 pounds.	Phosphoric Acid in 100 Pounds.								Potash in 100 Pounds.				Computed commercial value at Department rating. (See p.)	Selling price at the point of selection.	Sample number.
	Soluble in water.	Reverted.	Insoluble.	Total.		Available.		Present as muriate.	Present as sulphate.	Total.					
				Found.	Guaranteed.	Found.	Guaranteed.			Found.	Guaranteed.				
13.31	7.63	3.85	1.45	12.92	12.00	11.47	11.00	1.99	.....	1.98*	2.00	14.71	19.00	780
12.63	5.14	3.98	2.43	11.54	.....	9.12	.....	2.71	.....	2.71	.....	14.13	16.50	783
10.95	5.53	5.17	.63	11.37	11.00	10.69	10.00	1.64	.....	1.64	1.00	13.39	12.00	809
													.....	753
													20.00	1181	
10.12	6.88	3.62	2.37	12.87	11.00	10.50	10.00	1.75	.....	1.75	.....	14.17	14.00	1162
8.80	3.15	9.39	2.76	15.30	.....	12.54	.....	.....	5.92	5.92	.....	20.38	21.00	920
11.55	4.30	5.49	3.27	13.06	10.00	9.79	9.00	2.80	.38	3.18*	5.00	15.31	18.00	1085	
10.05	7.25	5.01	2.04	14.30	13.00	12.26	12.00	2.04	.....	3.04	2.00	16.47	18.50	710
													19.00	1175	
10.56	3.58	7.78	4.10	15.46	13.00	11.36	11.00	2.87	.....	2.87	2.00	16.05	18.00	843
													15.00	850	
10.43	8.87	2.84	.34	12.05	12.00	11.71	11.00	5.73	.....	5.73	5.00	18.48	18.50	722
													14.00	915	
													15.00	1031	
12.87	6.03	4.64	.66	11.27	11.00	10.67	10.00	2.16	.....	2.16	2.00	13.93	16.50	792
													14.50	1126	
13.55	6.53	4.60	.34	11.46	.....	11.12*	11.62	2.22	.....	2.22	2.00	14.22	19.00	1077
13.30	6.95	3.73	.50	11.18	.....	10.68	10.00	2.13	.....	2.13	2.00	14.04	25.00	728

*Constituent falls below guarantee.

ROCK AND POTASH

Sample number.	Manufacturer and Brand.	From Whom Sample Was Taken.
	R. H. POLLOCK, BALTIMORE, MD.	
812	†Victor Bone Phosphate,	W. H. Shearer, New Bloomfield, Pa., ...
697		J. G. Dubbs, Bellefonte, Pa.,
942		J. A. C. Rider, Tyrone, Pa.,
	THE RAMSBURG FERTILIZER CO., FREDERICK, MD.	
787	Alkaline Phosphate,	S. H. Duncan, Abbottstown, Pa.,
	JOHN S. REFSE, BALTIMORE, MD.	
981	H. G. Potash Mixture,	Frank Dine, Muncy, Pa.,
	ISAAC ROBINSON, BALTIMORE, MD.	
1046	Potashed Bone,	J. R. Shaffer, S. Danville, Pa.,
	SHENANDOAH FERTILIZER CO., SHENANDOAH, FA.	
914	Special Wheat,	John Penny, Dry Valley, Pa.,
1819	Special Wheat Grower,	A. D. Super, Friedensburg, Pa.,
	I. P. THOMAS & SON, PHILADELPHIA, PA.	
1066	Corn Fertilizer,	J. G. Lighton, Tunkhannock, Pa.,
	TUSCARORA FERTILIZER CO., PORT ROYAL, PA.	
800	†Bone and Potash,	John Rhoads, Millerstown, Pa.,
963		W. W. McDaniel, Everett, Pa.,
686		S. L. Stryker, Petersburg, Pa.,
992		Grier & Osterhout, Punxsutawney, Pa.,
1267		George Y. New, Blairsville, Pa.,
	WILLIAMS & CLARK FERTILIZER CO., NEW YORK.	
881	†Acorn Brand Acid Phosphate,	J. R. Coulter, Olivet, Pa.,
896		G. F. Cori, State College, Pa.,
807		H. S. Tressler, Newport, Pa.,
931		J. M. Fike, Geiger's (P. O. Bills, Pa.),
1106	Americus,	G. W. Rich, Smithfield, Pa.,

For explanation of these tables see page 27. †Composite sample.

FERTILIZERS—Continued.

Moisture in 100 pounds.	Phosphoric Acid in 100 Pounds.								Potash in 100 Pounds.				Computed commercial value at Department rating. (See p.)	Selling price at the point of selection.	Sample number.
	Soluble in water.	Reverted.	Insoluble.	Total.		Available.		Present as muriate.	Present as sulphate.	Total.					
				Found.	Guaranteed.	Found.	Guaranteed.			Found.	Guaranteed.				
10.63	5.63	4.35	.59	10.62	10.00	10.03	9.00	1.56	.....	1.56	1.00	12.88	14.00 16.00 17.60	813 997 943
11.70	6.86	4.39	4.19	15.35	11.25	10.00	1.45	1.45*	2.00	14.92		15.00	787
12.48	8.90	2.80	.42	12.12*	12.00	11.70*	12.00	4.00	4.00*	5.00	17.32		20.00	981
7.94	1.80	8.55	1.23	11.63*	12.00	10.35	10.00	2.02	.....	2.03	2.00	14.00	14.25	1046
11.03	5.14	5.43	2.35	12.92	.....	10.57	10.00	1.21	.....	1.21*	2.00	13.42	18.50	914
11.72	3.89	5.59	2.01	11.49	.....	9.48*	10.00	1.79	.....	1.79*	2.00	13.12	21.00	1219
10.12	2.48	6.83	2.79	12.15	12.00	9.30*	10.00	2.46	3.16	6.62	6.50	18.61	38.00	1095	
10.26	.84	6.45	2.80	10.89	8.00	7.29	7.00	.93	.....	.93*	1.00	10.96	12.00 14.00 16.00 17.00 18.00	800 962 686 992 1267
7.20	10.23	4.58	.94	15.80	15.00	14.86	14.00	.5151	15.42	 14.50 14.00 14.00	881 895 807 931
7.96	7.16	4.56	2.59	14.31	11.72	2.80	2.80	15.57		19.00	1106

*Constituent falls below guarantee.

ACIDULATED ROCK

Furnishing

Sample number.	Manufacturer and Brand.	From Whom Sample Was Taken.
	ALLEGHENY CITY FERTILIZER WORKS, ALLEGHENY, PA.	
757	Full Value Phosphate,	F. M. Baker, Huefner, Clarion Co., Pa.,
	WM. F. BAUGHMAN, RINELY, PA.	
852	Acid Phosphate,	A. E. March, P. O. Esaley, Weigelstown, Pa.
	D. BLOCHER & CO., GETTYSBURG, PA.	
714	} †Dissolved Bone Phosphate, {	J. F. Harshberger, Lewistown, Pa., {
958		Hershberger Bros., Everett, }
	BRADLEY & GREEN FERTILIZER CO., PHILADELPHIA, PA.	
863	H. G. Acid Phosphate,	Swisher & Fretz, Quarryville, Lancaster co., Pa.
	S. B. BRODBECKS, BRODBECKS AND GREENRIDGE, PA.	
797	} †Ruth's Dissolved Bone Phosphate, {	Sheaffer & Fry, Hanover, York Co., Pa., {
1124		Stewart Stevenson, Hookerstown, York Co., Pa. }
	BRUMFIELD & FOSTER, COLORA, CECIL CO., MD.	
839	H. G. Acid Phosphate,	D. R. Miller, Petersburg,
	J. A. CRANSTON CO., NEWPORT, DEL.	
1260	Horse Shoe Soluble Bone,	Richards & Owens, Fairville,
	LOUIS F. DETRICK, BALTIMORE, MD.	
1190	XXtra Acid Phosphate,	Cook, Bents & Co., Millsburg, York Co., Pa.,
	EUREKA FERTILIZER CO., PERRYVILLE, MD.	
885	K. & G. Acid Phosphate,	H. G. Kennedy, Apollo,
	CHAS. V. GEIGER, GEIGER'S MILLS, PA.	
1225	Corn, Oats and Wheat Special, No. 5,	Chas. V. Geiger, Hamburg, Pa.,
989	} †Corn, Oats and Wheat Special, No. 5, {	A. L. Kindt, Allenwood, Pa., {
1336		Chas. V. Geiger, Joanna, Pa., }

For explanation of these tables see page 27. †Composite sample.

PHOSPHATES.

Phosphoric Acid.

Moisture in 100 pounds.	Phosphoric Acid in 100 Pounds.							Computed commercial value at Department rating. (See p.)	Selling price at the point of selection.	Sample number.
	Soluble in water.	Reverted.	Insoluble.	Total.		Available.				
				Found.	Guaranteed.	Found.	Guaranteed.			
7.71	6.30	4.32	3.99	14.61	12.00	10.62*	11.50	11.76	16.00	787
12.00	6.34	6.25	3.59	16.18	.....	12.59	.....	12.81	12.50	852
9.08	11.93	2.40	1.64	17.02	14.00	15.38	12.00	14.44	{ 14.00 13.50	714 969
5.21	10.16	5.96	.32	16.94	16.00	16.12	14.00	14.40	12.50	863
11.06	11.22	2.42	.79	15.44	.....	14.65	.....	12.62	{ 12.50	797 1124
12.11	10.82	5.12	.36	16.26	.....	16.00	.....	14.22	15.00	839
12.22	10.91	2.27	1.94	16.22	16.00	14.28	14.00	12.77	12.00	1260
9.17	11.12	2.96	2.14	17.22	15.00	15.08	14.00	14.25	12.00	1190
2.51	2.68	7.42	2.32	13.38	12.00	10.00*	12.00	10.74	.....	885
7.27	2.22	7.52	5.57	16.42	.....	10.86	10.00	12.15	16.00	1225
7.75	4.44	6.15	5.07	15.66	.....	10.59	10.00	11.22	{ 20.00 15.00	969 1226

*Constituent falls below guarantee.

ACIDULATED ROCK

Sample number.	Manufacturer and Brand.	From Whom Sample Was Taken.
1065	W. S. HASTINGS & SON, ATGLEN, PA. Clear Acid Phosphate,	W. S. Hastings & Son, Atglen, Pa.,
	THE LACKAWANNA FERTILIZER CO., MOOSIC, PA.	
824	Acid Phosphate, MARYLAND FERTILIZER AND MANUFACTURING CO., BALTIMORE, MD.	C. V. Gruver, Howard, Pa.,
823	Dissolved S. C. Bone, McCAlMONT & CO., BELLEFONTE, PA.	Col. John A. Woodward, Howard, Pa.,
699	Florida Bone Phosphate,	J. S. McCAlmont, Bellefonte,
700	H. G. South Carolina Bone,	J. S. McCAlmont, Bellefonte,
	NIAGARA FERTILIZER WORKS, BUFFALO, N. Y.	
876	Dissolved Bone, J. DOUGLASS PERKINS, COATESVILLE, PA.	J. A. Blaney, Jr., Whitesburg,
1073	Perkins' H. G. Acidulated Phosphate, PITTSBURG PROVISION CO., PITTSBURG, PA.	J. Douglass Perkins, Coatesville,
883	Acid Phosphate, THE RAMSBURG FERTILIZER CO., FREDERICK, MD.	W. T. Wilson, Long Run, Pa.,
788	Dissolved Bone Super Phosphate, RASIN-MONUMENTAL CO., BALTIMORE, MD.	S. H. Duncan, Abbottstown, Pa.,
965	} †Sea Wall Special, {	H. Frank Gump, Everett, Pa.,
1246		William Davis, Greensboro, Pa.,
	SOUTHERN FERTILIZER CO., YORK, PA.	
1210	Dissolved Bone Phosphate, SUSQUEHANNA FERTILIZER CO., BALTIMORE, MD.	T. E. Sittler, Andreas,
860	} †Superior Rock Phosphate, {	S. Book & Bro., Quarryville, Lancaster Co. Pa.
1066		Jos. Worrall, Parkesburg, Pa.,

For explanation of these tables see page 27. †Composite sample.

PHOSPHATES—Continued.

Moisture in 100 pounds.	Phosphoric Acid in 100 Pounds.								Computed commercial value at Department rating. (See p.)	Selling price at the point of selection.	Sample number.
	Soluble in water.	Reverted.	Insoluble.	Total.		Available.					
				Found.	Guaranteed.	Found.	Guaranteed.				
7.72	10.33	4.94	2.24	17.56	.....	15.32	14.00	14.44	12.00	1066
14.40	9.93	4.45	.80	14.98*	15.00	14.38	14.00	13.26	11.75	824	
12.50	12.90	4.63	.45	18.98	14.50	18.53	14.00	16.17	12.00	823	
12.78	11.14	3.82	.39	15.35*	16.00	14.96	14.00	13.65	14.50	699	
8.65	11.89	3.82	.35	16.06	16.00	15.71	14.00	14.18	12.50	700	
9.76	9.93	5.44	1.54	16.91	15.00	15.37	14.00	14.17	17.00	876	
15.40	11.22	3.81	.33	15.36*	16.75	15.03*	15.49	13.68	12.50	1073	
3.97	.00	3.80	5.61	14.60	14.00	8.99*	12.00	10.70	.....	833
11.46	10.38	4.34	1.77	16.99	16.00	15.22	14.00	14.30	12.50	728	
10.52	2.73	3.32	3.03	14.08	11.50	11.05	10.00	11.26	{ 12.00 15.00	955 1246	
10.43	9.57	4.94	1.06	15.57	15.00	14.51	14.00	12.44	16.00	1210	
9.67	11.00	2.87	1.10	15.97	15.00	14.87	14.00	12.82	{ 18.00 12.50	880 1068	

*Constituent falls below guarantee.

ACIDULATED ROCK

Sample number.	Manufacturer and Brand.	From Where Sample Was Taken.
	I. P. THOMAS & SON, PHILADELPHIA, PA.	
1060	{ †Dissolved Phosphate, { 1220 887 945 777 1144 { †S. C. Phosphate, { 1309 1322	Cittner & Diehl, Washingtonville, Pa., .
		Benjamin Sunday, Hamburg, Pa.,
		W. A. Miller, Neff's Mills, Pa.,
		W. J. Diehl, Bedford, Pa.,
		D. F. Stitzel, Dillsburg,
		Levi Miller, Sinking Springs, Pa.,
		Beyers & Lenis, Honeybrook, Pa.,
		C. H. Moyer, Cresona,
	TUSCARORA FERTILIZER CO., PORT ROYAL, PA.	
1266	Dissolved Bone Phosphate,	Geb. J. New, Blairsville,
	WALKER, STRATMAN & CO., PITTSBURG, PA.	
1115	Help Mate,	Chas. Redd, Cowansville, Pa.,
	THE WALTON FERTILIZER CO., CLEVELAND, O.	
1243	Special Dissolved Bone Phosphate,	Nicely & Lelpert & Waterson, Darlington,
1244	Triumph Phosphate,	Nicely & Lelpert & Waterson, Darlington,
	W. E. WHANN, PHILADELPHIA, PA.	
1238	Whann's S. C. Phosphate,	S. C. Keller, Lyons, Pa.,
	M. E. WHEELER & CO., NEW YORK.	
970	H. G. Electrical Bone Fertilizer,	S. A. Eder, Montoursville, Pa.,

For explanation of these tables see page 27. †Composite sample.

PHOSPHATES—Continued.

Moisture in 100 pounds.	Phosphoric Acid in 100 Pounds.								Computed commercial value at Department rating. (See p.)	Selling price at the point of selection.	Sample number.
	Soluble in water.	Reverted.	Insoluble.	Total.		Available.					
				Found.	Guaranteed.	Found.	Guaranteed.				
2.77	2.01	8.71	5.68	16.40	11.00	10.72	10.00	11.91	{ 13.00 14.00 13.00 14.00 13.00	1060	
										1230	
										837	
										945	
										777	
9.09	10.42	4.41	2.18	16.96	16.00	14.83	14.00	14.11	14.00	1144	
									13.00	1309	
									13.00	1332	
5.23	.65	4.77	5.47	10.89	8.00	5.42	7.00	8.52	13.00	1266	
10.50	6.94	5.59	2.50	15.03	12.00	12.53	11.50	12.46	.....	1115
12.07	11.06	3.88	2.30	17.24	13.00	14.94	12.00	14.32	16.00	1243	
10.23	2.59	7.09	1.82	11.50	9.00	9.68	8.00	9.98	14.50	1244	
10.78	11.00	4.43	.88	16.31	.....	15.43	14.00	14.11	15.00	1238
8.41	11.26	3.86	.27	15.39*	16.00	15.12	14.00	13.72	15.00	970	

*Constituent falls below guarantee.

GROUND BONE

Furnishing Phosphoric

Sample number.		
	Manufacturer and Brand.	From Whom Sample Was Taken.
	BAUGH & SONS CO., PHILADELPHIA, PA.	
957	Bone Meal, warranted pure,	A. M. McClure, Everett, Pa.,
	BRADLEY FERTILIZER CO., NEW YORK.	
1015	Bradley's Fine Ground Bone,	E. W. Rupp, Shiremanstown, Pa.,
	CUMBERLAND BONE PHOSPHATE CO., PORTLAND, ME.	
925	Cumberland Extra F. G. Bone,	J. J. Zimmerman, Stoyestown, Pa.,
	S. M. HESS & BRO., PHILADELPHIA, PA.	
743	Ground Bone,	A. E. Mock, Martinsburg, Pa.,
	R. H. POLLOCK, BALTIMORE, MD.	
1009	Ground Animal Bone,	Elias Gable, Red Lion, Pa.,
	THE QUINNIPIAC CO., NEW YORK.	
910	Uncas Bone Meal,	J. W. Painter & Co., Red Top, Pa.,
	JOHN S. REESE & CO., BALTIMORE, MD.	
1295	Fine Ground Bone,	Ball & Rhoads, Media, Pa.,
	SCOTT FERTILIZER CO., ELKTON, MD.	
861	Pure Ground Raw Bone,	S. Book & Bro., Quarryville, Pa.,
	M. L. SHOEMAKER & CO., PHILADELPHIA, PA.	
1263	Swift Sure Bone Meal,	Bennett & Lear, West Chester, Pa.,
	SUSQUEHANNA FERTILIZER CO., BALTIMORE, MD.	
1063	Pure Ground Bone,	Geo. B. Passmore Sons, Oxford, Pa.,
	TAYLOR PROVISION CO., TRENTON, N. J.	
1274	Pure Bone Meal,	Isaac W. Holcombe, New Hope, Pa.,
	I. P. THOMAS & SON CO., PHILADELPHIA, PA.	
954	Pure Ground Animal Bone,	H. Frank Gump, Everett, Pa.,
	TYGERT-ALLEN FERTILIZER CO., PHILA., PA.	
1242	"Prairie Bone Meal,"	H. G. Shepler, El'verson, Pa.,

For explanation of these tables see page 27. †Composite sample.

FERTILIZERS.**Acid and Nitrogen.**

Moisture in 100 pounds.	Mechanical Analysis.		Chemical Analysis.				Computed commercial value at Department rating. (See p.)	Selling price at the point of selection.	Sample number.
	Diameter less than 1-50 inch, "fine."	Diameter greater than 1-50 inch, "coarse."	Phosphoric Acid.		Nitrogen.				
			Found.	Guaranteed.	Found.	Guaranteed.			
6.59	81	9	21.95	21.50	3.72	3.50	29.68	30.00	957
8.11	77	23	23.50	.....	2.68	.....	27.28	30.00	1015
3.11	54	14	16.63	.....	1.60*	1.65	20.11	26.00	925
4.57	55	45	25.77	12.74	2.92	2.47	27.15	.....	743
7.30	48	52	23.22	.....	3.98	.....	27.20	30.00	1009
3.06	76	24	21.44	.....	2.19	1.99	24.45	23.00	910
5.45	84	16	18.37	.....	3.47	.....	25.64	30.00	1295
7.93	45	55	23.62	22.60	3.82	3.30	26.71	31.00	961
3.50	89	11	24.81	.....	4.65	4.12	24.08	30.00	1363
3.37	51	49	24.68	20.00	3.93	3.30	25.28	28.00	1068
3.73	87	13	26.63	25.00	2.82	2.50	30.94	29.00	1871
2.96	75	25	25.24	21.00	2.88	.....	28.86	30.00	954
3.48	88	12	18.47	18.00	2.00	2.47	22.63	28.00	1342

*Constituent falls below guarantee.

GROUND BONE

Sample number.	Manufacturer and Brand.	From Whom Sample Was Taken.
	WALKER, STRATMAN & CO., PITTSBURG, PA.	
1113	Pure Raw Bone Meal,	Chas. Redd, Cowansville, Pa.,
	F. K. WALT & CO., WAYNESBURG JCT., PA.	
1080	Ground Animal Bone,	Geo. B. Pyle, Cain, Pa. (P. O. Coatesville, Pa.)
	WILLIAMS & CLARK FERTILIZER CO., NEW YORK.	
1255	Pure Bone Meal,	S. J. Saint, Sharpsburg, Pa.,
	YORK CHEMICAL WORKS, YORK, PA.	
796	Pure Fine Ground Raw Bone,	Jesse S. Brodbeck, Hanover, Pa.,

For explanation of these tables see page 27. †Composite sample.

FERTILIZERS—Continued.

Moisture in 100 pounds.	Mechanical Analysis.		Chemical Analysis.				Computed commercial value at Department rating. (See p.)	Selling price at the point of selection.	Sample number.
	Diameter less than 1-50 inch, "fine."	Diameter greater than 1-50 inch, "coarse."	Phosphoric Acid.		Nitrogen.				
			Found.	Guaranteed.	Found.	Guaranteed.			
5.53	62	38	21.77*	22.00	3.10	3.88	25.51	.....	1113
5.09	60	40	18.84	.....	2.75	.....	22.52	22.00	1080
6.90	58	42	24.36	22.90	3.73	.....	28.41	28.00	1265
5.75	52	48	23.55	22.00	3.82	3.30	27.29	30.00	796

*Constituent falls below guarantee.

DISSOLVED BONE
Furnishing Phosphoric

Sample number.	Manufacturer and Brand.		From Whom Sample Was Taken.	
	PITTSBURG PROVISION CO., PITTSBURG, PA.			
832	Guano Fertilizer,		W. A. Lambing, Olivet,	
	I. P. THOMAS & SON CO., PHILADELPHIA, PA.			
1084	Raw and Dissolved Bone,		Wells & Walker, Downingtown,	

For explanation of these tables see page 27. †Composite sample.

FERTILIZERS.

Acid and Nitrogen.

Moisture in 100 pounds.	Phosphoric Acid in 100 Pounds.								Nitrogen in 100 Pounds.		Computed commercial value of 2,000 pounds at Department rating. (See p. .)	Selling price at the point of selection.	Sample number.
	Soluble in water.	Reverted.	Insoluble.	Total.		Available.		Found.	Guaranteed.				
				Found.	Guaranteed.	Found.	Guaranteed.						
2.74	2.03	4.34	5.03	11.40	11.00	6.37*	9.00	1.99	1.65	21.40	.....	332
5.45	3.90	4.13	11.20	19.23	.....	8.03	8.00	1.69	1.65	24.07	22.50	1084

*Constituent falls below guarantee.

MISCELLANEOUS
FURNISHING

Sample number.	Manufacturer and Brand.	From Whom Sample Was Taken.
	MARYLAND FERTILIZER AND MANUFACTURING CO., BALTIMORE, MD.	
323	Muriate of Potash,	Col. John A. Woodward, Howard, Pa.,
	MILSOM RENDERING AND FERTILIZER CO., EAST BUFFALO, N. Y.	
761	Muriate of Potash (Guar. 50 per cent.),	W. J. Cowan, Corsica, Pa.,

FERTILIZERS.

POTASH.

Moisture in 100 pounds.	Potash in 100 Pounds. (Water Soluble.)				Computed commercial value of 2,000 pounds at Department rating. (See p. .)	Selling price of 2,000 pounds at the point of selection.	Sample number.
	Present as muriate.	Present as sulphate.	Total.				
			Found.	Guaranteed.			
5.23	48.00	.....	48.60	.....	51.57	48.00	822
6.27	45.61	.....	45.61	.....	48.51	.....	761



LIST

OF

FERTILIZER MANUFACTURERS

WHO TOOK OUT

Licenses for the Sale of Commercial Fertilizers

IN

PENNSYLVANIA IN 1900,

TOGETHER WITH A LIST OF THE

VARIOUS BRANDS OFFERED FOR SALE.



FERTILIZER MANUFACTURERS WITH A LIST OF THEIR BRANDS OF GOODS ON SALE IN 1900.

ALLEGHENY CITY FERTILIZER WORKS, Allegheny, Pa

1. "Raw Bone Phosphate."
2. "Raw Bone Meal."
3. "Potato Manure."
4. "Special Lawn and Garden Fertilizer."
5. "Banner Phosphate."
6. "Full Value Phosphate."
7. "Dissolved Bone and Potash."

ALLENTOWN MANUFACTURING COMPANY, Allentown, Pa.

1. "Pure Ground Bone."
2. "High Grade Truck Phosphate."
3. "High Grade Potato Phosphate."
4. "Complete Bone Phosphate."
5. "Special \$25 Phosphate."
6. "Phosphate and Potash."
7. "Acidulated Phosphate."

ALLIANCE FERTILIZER COMPANY, Alliance, Ohio.

1. "Farmers' Friend."

AMERICAN REDUCTION COMPANY, Pittsburg, Pa.

1. "Iron City."
2. "Common Sense."
3. "Vegetable Manure."
4. "Fine Ground Bone."

J. L. AMWAY, Mt. Joy, Pa.

1. "Improved Phosphate."

A. ANSTINE, Stewartstown, Pa.

1. "Bone Phosphate."

THE ARMOUR FERTILIZER WORKS, No. 205 La Salle Street, Chicago, Ill.

1. "Bone, Blood and Potash."
2. "Fruit and Root Crop Special."
3. "Grain Grower."
4. "Ammoniated Bone with Potash."
5. "Phosphate and Potash."
6. "Wheat Special."
7. "Wheat, Corn and Oats Special."
8. "Bone Meal."
9. "Star Bone."

10. "All Soluble."
11. "Armour's High Grade Potato Fertilizer."

ARMOUR PACKING COMPANY, Kansas City, Mo.

1. "Armour's Flower Food."

R. S. AUCKER, Shamokin, Pa.

1. "Pure Ground Bone Meal."
2. "High Grade Bone and Slaughter House Phosphate."
3. "Grade A."
4. "Grade B."
5. "Grade C."
6. "High Grade Acid Phosphate."
7. "Bone Meal with Potash."
8. "Special Potato and Truck Phosphate."

BALTIMORE PULVERIZING COMPANY, No. 2, Marine Bank Building, Baltimore, Md.

1. "Special Spring and Fall Mixture."
2. "Special Mixtures."

J. H. BARTENSCHLAGER, Stewartstown, Pa.

1. "Champion Bone Phosphate."

BAUGH AND SONS COMPANY, No. 20 S. Delaware Avenue, Philadelphia, Pa.

1. "Baugh's Bone Meal—Warranted Pure."
2. "Baugh's Pure Dissolved Animal Bones."
3. "Export Bone with Potash."
4. "Baugh's Special Potato Manure."
5. "Baugh's Animal Bone and Potash Compound for all Crops."
6. "Baugh's \$25 Phosphate."
7. "Baugh's Double Eagle Phosphate."
8. "Baugh's General Crop Grower for all Crops."
9. "Baugh's Soluble Alkaline Super-Phosphate."
10. "Wheat Fertilizer for Wheat and Grass."
11. "Potato Fertilizer."
12. "Baugh's Corn Fertilizer for Sugar Corn and Garden Truck."
13. "Baugh's High Grade Acid Phosphate."
14. "The Wrapper Leaf Brand."

WILLIAM F. BAUGHMAN, Rinley, Pa.

1. "Harvest Queen Phosphate."
2. "Ammoniated Bone Phosphate."
3. "P. & T. Special."
4. "Baughman's Bone and Potash."
5. "Acid Phosphate."

HENRY V. BAXTER, Chester, Pa.

1. "Pure Ground Bone."
2. "I. X. L. Phosphate."

W. C. BECKERT, Allegheny, Pa.

- 1 "Odorless Special Lawn and Garden Fertilizer."

THE BERG COMPANY, Port Richmond, Philadelphia, Pa.

1. "Berg's \$35 Potato Manure."
2. "Berg's Standard Bone Manure."
3. "Berg's Pure Dissolved Bone and Potash."
4. "Berg's Raw Bone Fine."
5. "Berg's Special \$25 Bone Manure."
6. "Berg's Trucker's Joy Guano."
7. "Berg's Lymph Guano, for all Crops."
8. "Berg's Special Potato Guano."
9. "Berg's Tobacco Manure."

BERGER BROS., Glendon, Pa.

1. "Berger Bros. Peerless."
2. "Berger Bros. Wheat and Grass Special."
3. "Berger Bros. Potato and Truck Special."
4. "Berger Bros. Lehigh Super-Phosphate."
5. "Berger Bros. High Grade Acid Phosphate."

A. H. BLAKER & CO., Fox Chase, Philadelphia, Pa.

1. "Special for Wheat and Corn."
2. "Special for General Use."
3. "Special for Potatoes."
4. "Special for Wheat and Grass."
5. "Poudrette Phosphate."
6. "Alkaline Bone."

D. BLOCHER & CO., Gettysburg, Pa.

1. "Dissolved Raw Bone and Potash."
2. "High Grade Super-Phosphate of Bone."
3. "Ammoniated Soluble Bone Phosphate."
4. "South Carolina."
5. "Dissolved Bone Phosphate."
6. "Alkaline Bone."

JAMES BONDAY, JR., & CO., Baltimore, Md.

1. "Sulphate of Potash."
2. "Muriate of Potash."
3. "German Kainit."

BOWKER FERTILIZER COMPANY, No. 43 Chatham Street, Boston, Mass.

1. "Stockbridge Potato Manure."
2. "Bowker's Ammoniated Dissolved Bone."
3. "Bowker's Farm and Garden Phosphate."
4. "Bowker's Six Per Cent. Potato Fertilizer."
5. "Bowker's Market Garden Fertilizer."
6. "Bowker's Potash Bone."
7. "Bowker's Potato and Vegetable Fertilizer."

8. "Bowker's Empire State Bone and Potash."
9. "Bowker's Potash or Staple Phosphate."
10. "Bowker's Harvest Bone."
11. "Bowker's Apex Bone."
12. "Dissolved Bone Phosphate."
13. "Bowker's Dissolved Bone Phosphate and Potash."
14. "Bowker's Wheat Grower."
15. "Bowker's Sure Crop Phosphate."
16. "Bowker's Super-Phosphate with Potash."
17. "Bowker's Ammoniated O. I. O. Bone Phosphate."

D. M. BOYD, Jr., Danville, Pa.

1. "Pure Ground Bone."
2. "Farmer's Champion."

BRADLEY FERTILIZER COMPANY, No. 92 State Street, Boston, Mass.

1. "Bradley's Niagara Phosphate."
2. "Bradley's Dissolved Bone with Potash."
3. "Bradley's Potato Fertilizer."
4. "Bradley's B. D. Sea Fowl Guano."
5. "Bradley's Alkaline Bone."
6. "Bradley's Soluble Dissolved Bone."
7. "Abattoir Bone Dust."
8. "Bradley's Bean and Potato."

BRADLEY AND GREENE FERTILIZER COMPANY, Ninth Street below Girard Avenue, Philadelphia, Pa.

1. "Popular Phosphate Soluble for Wheat."
2. "Standard Bone Phosphate for Corn, Wheat and Peas."
3. "Potato Guano No. 1."
4. "Harvest Home Phosphate."
5. "Pure Ground Bone."
6. "Market Garden."
7. "High Grade Acid Phosphate."
8. "High Grade Special Tobacco."

HORACE BRILLINGER, Emigsville, Pa.

1. "Brillinger's Special Wheat, Corn and Grass Mixture."
2. "Brillinger's Standard High Grade Phosphate."

R. WILLIAM BREAM, Gettysburg, Pa.

1. "Bream's Grain and Truck Fertilizer."

ELIAS S. BRUBACKER, Millbach, Pa.

1. "Wheat and Grass Special."

THE BUCYRUS FERTILIZER COMPANY, Bucyrus, Ohio.

1. "Superior Pure Ground Bone."
2. "Bucyrus Fine Steamed Bone."
3. "Keystone Potato and Truck Special."

4. "Super-Phosphate with Potash."
5. "Buckeye Wheat Grower."
6. "Natural Plant Food."
7. "Dissolved Bone with Potash."
8. "Dissolved Bone."

CAMBRIA FERTILIZER COMPANY, Johnstown, Pa.

1. "Pure Ground Bone Dust."
2. "Lion Phosphate."
3. "Standard Phosphate."
4. "Corn and Potato Manure."
5. "B. & B. Phosphate."

CHAMPION FERTILIZER COMPANY, Cleveland, Ohio.

1. "Woukeska Bone."
2. "Western Reserve Dissolved Bone."
3. "Ammoniated Soluble Bone."
4. "Hero Phosphate."
5. "Bone Meal and Potash."
6. "XX Hoosier Phosphate."

CHEMICAL COMPANY OF CANTON, P. O. Box 407, Baltimore, Md.

1. "Baker's Special Wheat, Corn and Grass."
2. "Baker's Pure Dissolved South Carolina Bone."
3. "Baker's Standard Guano."
4. "Baker's Dissolved Bone Phosphate."
5. "Soluble Bone and Potash."
6. "Resurgam Guano."
7. "Baker's Fish Guano."
8. "Harrow Brand Crop Grower."
9. "Potato Manure."
10. "C. C. C. Special Potato Manure."
11. "Soluble Alkaline Bone."
12. "Baker's Standard Ground Bone."
13. "Patrons Bone Mixture."
14. "Game Guano."
15. "B. S. Amm. Bone Phosphate."
16. "Eagle Phosphate."

CHICAGO FERTILIZER COMPANY, Chicago, Ill.

1. "Bone, Blood and Potash."
2. "Mt. Pleasant Phosphate."
3. "Wheat Special Phosphate."
4. "Chicago Bone Meal."

CHICOPEE GUANO COMPANY, No. 88 Wall Street, New York, N. Y.

1. "Harvest Favorite."
2. "Farmers' Reliable."
3. "Standard Guano."
4. "Special High Grade Guano."
5. "Improved Standard Guano."

CLARK'S COVE FERTILIZER COMPANY, P. O. Box 1779, New York, N. Y.

1. "Clark's Cove King Philip Alkaline Guano."
2. "Clark's Cove Defiance Complete Manure."
3. "Clark's Cove Potato and Hop Grower."
4. "Clark's Cove Triumph Bone and Potash."
5. "Clark's Cove Atlas Bone Phosphate."
6. "Clark's Cove Sunflower Bone Meal."

E. FRANK COE COMPANY, No. 133 Front Street, New York, N. Y.

1. "High Grade Bone."
2. "Standard Grade Phosphate."
3. "XXX Phosphate."
4. "Special Potato Fertilizer."
5. "Alkaline Bone."
6. "Pennsylvania Grain Special."
7. "Prize Brand Grain."
8. "E. Frank Coe's Knickerbocker Phosphate."
9. "Empire State Brand."
10. "Western New Yorker."
11. "High Grade Acid Phosphate."
12. "Dissolved Bone Potash."

HENRY COPE AND COMPANY, Lincoln University, Pa.

1. "Pure Bone Phosphate."
2. "Ammoniated Phosphate."
3. "Acid Phosphate."
4. "Dead Shot Phosphate."
5. "Soluble Bone and Potash."
6. "Pure Ground Bone."
7. "Queen of Elk Valley Phosphate."
8. "Steamed Bone."
9. "Special Chester County Potato and Corn Phosphate."
10. "Pennsylvania Wheat Grower and Complete Manure."

JOSIAH COPE & CO., Lincoln University, Pa.

1. "Acidulated Phosphate."
2. "Pure Bone Phosphate."
3. "Try Me Bone Phosphate."
4. "Soluble Bone and Potash."
5. "Ammoniated Bone Phosphate."
6. "Wheat and Grass Special Phosphate."
7. "Potato and Tobacco Phosphate."
8. "Pure Ground Bone."

J. A. CRANSTON COMPANY, Wilmington, Delaware.

1. "Pennsylvania Superior Phosphate."
2. "W. B. Raw Bone Super-Phosphate."
3. "Raw Bone Meal."
4. "Horse Shoe Soluble Bone Phosphate."
5. "Horse Shoe Soluble Bone and Potash."

CROCKER FERTILIZER AND CHEMICAL COMPANY, Buffalo, N. Y.

1. "Dissolved Bone."
2. "Potato, Hop and Tobacco."
3. "Ammoniated Bone Super-Phosphate."
4. "Special Potato Manure."
5. "New Rival Ammoniated Super-Phosphate."
6. "Universal Grain Grower."
7. "Ammoniated Wheat and Corn Phosphate."
8. "General Crop Phosphate."
9. "Crocker's Ground Bone."
10. "Dissolved Bone and Potash."
11. "Complete Manure."
12. "Harvest Jewel."

CUMBERLAND BONE PHOSPHATE COMPANY, No. 27, William Street, New York, N. Y.

1. "Cumberland Guano."
2. "Cumberland Seeding Down Phosphate."
3. "Cumberland Bone and Potash."
4. "Cumberland Extra Fine Ground Bone."
5. "Cumberland Potato Phosphate."
6. "Cumberland Dissolved Bone Phosphate."
7. "Cumberland Ammoniated Dissolved Bone."

E. DARON, Dover, Pa.

1. "Daron's Harvest King Phosphate."

WM. DAVISON & CO., Baltimore, Md.

1. "Penn-Mar Ammoniated Bone Phosphate."

DETRICK FERTILIZER AND CHEMICAL COMPANY, No. 26, Chamber of Commerce, Baltimore, Md.

1. "Detrick's Standard Potash Fertilizer."
2. "Detrick's Imperial Compound."
3. "Detrick's Special Mixture."
4. "Detrick's Potato Fertilizer."
5. "Detrick's Ammoniated Bone Phosphate."
6. "Detrick's Royal Crop Grower for Grain and Grass."
7. "Soluble Bone Phosphate and Potash."
8. "Dissolved South Carolina Bone."
9. "P. & B. Special Fertilizer."
10. "Detrick's Ammoniated Super-Phosphate (The Crop Producer)."
11. "Paragon Ammoniated Bone Phosphate and Potash."
12. "Detrick's Corn and Oats Fertilizer."

LOUIS F. DETRICK, No. 26, Chamber of Commerce, Baltimore, Md.

1. "Kangaroo Komplete Kom pound."
2. "XXtra Acid Phosphate."
3. "Bone and Potash Mixture."
4. "Sockless and Shoeless Phosphate."

5. "Orchilla Guano."
6. "Bone and Potash (16x4) Mixture."

H. E. DOOLEY, Delta, Pa.

1. "Pennsylvania Special Mixture."

WALLACE DUNGAN, Doylestown, Pa.

1. "Bone Flour."
2. "Pebble Hill Home Made Animal Bone Mixture."

EASTERN CHEMICAL COMPANY, No. 620 Atlantic Avenue, Boston, Mass

1. "Imperial Liquid Plant Food."

AMOS EBY, Paradise, Pa.

1. "Pequea Bone."
2. "Pequea Phosphate."
3. "Pequea Economy."
4. "Pequea Ammoniated Phosphate."
5. "Pequea Bone for Potatoes."

EUREKA FERTILIZER COMPANY, Perryville, Md.

1. "P. & P. Super-Phosphate."
2. "Grain and Grass Mixture."
3. "Corn and Potato Special."
4. "Alkaline Bone and Potash."
5. "Ground Bone."
6. "Potato and Vegetable Fertilizer."
7. "Farmers' Favorite Bone Phosphate."
8. "Imperial Bone Phosphate."
9. "Fish, Rock and Potash."
10. "K. & G. Acid Phosphate."
11. "Standard Bone Phosphate."
12. "Pure Dissolved Bone."

WASHINGTON EWING, Landenberg, Pa.

1. "Pure Raw Bone."
2. "Eclipse Bone Phosphate."
3. "Wasteland Potato Phosphate."

FAIRLAMB, R. C., & SONS, Brandywine Summit, Pa.

1. "Potato Special."
2. "Corn Special."
3. "Wheat and Grass."

FARMERS' FERTILIZER COMPANY, Westminster, Md.

1. "No. 1 Bone Phosphate."
2. "No. 3 Bone Phosphate."
3. "XX Bone Phosphate."

4. "P. A. & P. Phosphate."
5. "Carroll Bone Phosphate."
6. "Acid Phosphate."

FARMER, W. S., & CO., No. 21, S. Gay Street, Baltimore, Md.

1. "Standard Phosphate."
2. "Harvest Queen."
3. "Clyde Brand."
4. "B. & P. Phosphate."
5. "Dissolved South Carolina Bone."

FOGLEMEN, W. H., Williamsport, Pa.

1. "Pure Bone and Potash."

FRETZ, MAHLON, Sellersville, Pa.

1. "Fretz's Standard Phosphate."
2. "Fretz's Fish Guano."

FRETZ, H. E., Bedminster, Pa.

1. "Fretz's Harvest Queen."

FULTON, JAS., & SONS CO., Stewartstown, Pa.

1. "Fulton's Potato, Wheat and Corn Fertilizer."
2. "Fulton's Bone Tankage."

GAWTHROP, JOSEPH R., Kennett Square, Pa.

1. "Fine Ground Raw Bone Meal."
2. "Complete Ammoniated Bone Phosphate."
3. "Champion Bone Fertilizer."
4. "Acid Phosphate Rock."
5. "Special Potato and Truck Phosphate."

GEIGER, CHAS. V., Geiger's Mills, Pa.

1. "Try Me Brand No. 7."
2. "Corn, Oats and Wheat Special."
3. "High Grade Acid Phosphate."
4. "Try Me For Potatoes, Etc."
5. "Try Me Brand—Dissolved Bone and Potash for Wheat, Etc."

GEMMILL, A. S., Stewartstown, Pa.

1. "Gemmill's High Grade Mixture."

GREAT EASTERN FERTILIZER CO., Rutland, Vt.

1. "General."
2. "Vegetable, Vine and Tobacco."
3. "Wheat Special."
4. "English Wheat Grower."
5. "Soluble Bone and Potash."
6. "Dissolved Bone."
7. "Pure Bone."

8. "Garden Special."
9. "Northern Corn Special."

GRIFFITH & BOYD, No. 9, S. Gay Street, Baltimore, Md.

1. "High Grade Acid Phosphate."
2. "Spring Crop Grower."
3. "Harvest Queen."
4. "Peerless Fertilizer."
5. "Valley Fertilizer."
6. "Cereal Bone Plant Food."
7. "Ammoniated Soluble Bone."
8. "Double Strength Tobacco Grower."
9. "Ammoniated Bone Phosphate."
10. "Genuine German Kainit."
11. "Special Guano."
12. "Farmers' Potato Manure."
13. "XX Potash Manure."
14. "Original Super-Phosphate."
15. "Farmers' Improved Phosphate."

HAGER, H. F., Quakertown, Pa.

1. "Hager's Ammoniated Super-Phosphate."
2. "Farmers' Favorite Phosphate."
3. "Panic Phosphate."

HANOVER BONE FERTILIZER CO., Hanover, Pa.

1. "Hanover Pure Bone Meal."
2. "Hanover Klondyke Special."
3. "Hanover Excelsior Combine."
4. "Hanover Blood and Bone Compound."
5. "Hanover Farmers' Crop Winner."
6. "Hanover Dissolved Bone Phosphate."
7. "Acid Phosphate."

HASTINGS, WM. S., Atglen, Pa.

1. "Clear Acid Phosphate."
2. "Octoraro No. 1 Bone Phosphate."

HESS, S. M., & BRO., S. E. Cor. Fourth and Chestnut Streets, Philadelphia, Pa.

1. "Ammoniated Bone Super-Phosphate."
2. "Keystone Bone Phosphate."
3. "Emperor Phosphate."
4. "Potato and Truck Manure."
5. "Ground Bone."
6. "High Grade Acid Phosphate."
7. "Special Compound."
8. "Soluble Bone."
9. "Wheat and Grass Manure."
10. "Special Corn Manure."
11. "Tobacco Manure."
12. "Soluble Bone and Potash."

HEWETT, F. H., & SON, Scranton, Pa.

1. "Market Bone Fertilizer."
2. "Pure Ground Bone."
3. "Odorless Lawn Dressing."

HUBBARD, M. P., & CO., No. 612 Equitable Building, Baltimore, Md.

1. "Farmers' Old Economy."
2. "Farmers' Acme."
3. "Harvest King."
4. "Soluble Bone and Potash."
5. "Celebrated Dissolved Bone."

HUBBARD AND COMPANY, No. 708 Merchants' Bank Building, Baltimore, Md.

1. "Wheat Growers' Jewel."
2. "Farmers' IXL Super-Phosphate."
3. "Oriental Phosphate for Wheat and Grass."
4. "Columbia Gem Phosphate."
5. "Hubbard & Co.'s Soluble Bone and Potash."
6. "High Grade Soluble South Carolina Phosphate."
7. "Hubbard's Standard Bone Super-Phosphate."
8. "Crescent Soluble Crop Producer."
9. "Kainit."

INDEX COMPANY, THE, No. 426 N. Third Street, Philadelphia, Pa.

1. "Index Bone Phosphate."
2. "Index Bone Meal."
3. "Index Bone Flour."
4. "Index Ground Bone."
5. "Index Radix Fertilizer."

INTERNATIONAL SEED COMPANY, Rochester, N. Y.

1. "Grain and Grass Fertilizer."
2. "Potato and Truck Manure."
3. "A 1. Special Manure."
4. "International Electric Guano."

JARECKI CHEMICAL COMPANY, THE, Sandusky, O.

1. "Lake Erie Fish Guano."
2. "No. 1 Fish Guano."
3. "Fish and Potash Grain Special."
4. "C. O. D. Phosphate."
5. "Ground Bone."
6. "Fish and Potash, Tobacco and Potato Food."
7. "O. K. Fertilizer."

JONES, W. C., SONS, Doe Run, Pa.

1. "High Grade Dissolved South Carolina Rock."
2. "Complete Fertilizer."
3. "Cereal Crop Grower."

KENDERDINE, T. S., & SONS, Newtown, Pa.

1. "Kenderdine's Bone Phosphate."
2. "Kenderdine's Potato Phosphate."
3. "Kenderdine's Ammoniated Phosphate."

**KEYSTONE CHEMICAL FERTILIZER COMPANY, No. 3 S. Front Street,
Philadelphia, Pa.**

1. "Keystone Special Potato Manure."
2. "Keystone Cereal Bone Phosphate."
3. "Keystone Harvest Queen Phosphate."
4. "Keystone Wheat and Grass Grower."
5. "Keystone Soluble Bone."

KRUG, GEO. F., Kingsdale, Pa.

1. "Ammoniated Bone Phosphate."
2. "XX Acid Phosphate."

KUHNS, DAVID, Lehighton, Pa.

1. "Pure Bone Meal."

KURTZ & STUNKARD, Green Bank, Pa.

1. "Conestoga Regulator."
2. "Conestoga Fancy Fertilizer."

LACKAWANNA FERTILIZER AND CHEMICAL COMPANY, Moosic, Pa.

1. "Moosic Phosphate."
2. "Bone Super-Phosphate."
3. "Warranted Pure Ground Bone."
4. "Special Manure."
5. "Alkaline Bone."
6. "Acid Phosphate."
7. "Admiral Dewey."
8. "Big Yield."

LANCASTER CHEMICAL COMPANY, Lancaster, Pa.

1. "Tobacco and Vegetable."
2. "Dewey Brand."
3. "Pure Dissolved Animal Bone and Potash."
4. "Rising Sun Animal Bone."
5. "Flag Brand."
6. "Pure Dissolved Animal Bone."
7. "Pure Raw Bone Meal."
8. "Hard Times Fertilizer."
9. "Economy Fertilizer."
10. "Acid Phosphate."

LAUBENSTEIN, REUBEN, Cressona, Pa.

1. "Raw Bone Phosphate."

LAZARETTO GUANO COMPANY, Merchants' National Bank Building, Baltimore, Md.

1. "Ammoniated Bone Phosphate."
2. "Retriever Animal Bone Fertilizer."
3. "Dissolved Bone Phosphate."
4. "Dissolved Bone and Potash."
5. "Excelsior A. A. A."
6. "Bone Compound Potash."

LEATHERBURY, A. B., Chester, Pa.

1. "The Chester Brand Bone Phosphate."

LEVAN, DANIEL, Lebanon, Pa.

1. "General Crop Grower."
2. "Wheat and Grass Special."
3. "Special Wheat Producer."

LISTER'S AGRICULTURAL CHEMICAL WORKS, Newark, N. J.

1. "Special Crop Producer."
2. "Corn Fertilizer No. 2."
3. "Special Wheat Fertilizer."
4. "Animal Bone and Potash No. 2."
5. "Special 10 Per Cent. Potato."
6. "Animal Bone and Potash."
7. "Perfect Fertilizer."
8. "Celebrated Ground Bone."
9. "Crescent Bone Dust."
10. "Pure Raw Bone Meal."
11. "U. S. Super-Phosphate."
12. "Potato Fertilizer No. 2."
13. "Standard Pure Bone Super-Phosphate of Lime."
14. "Ammoniated Dissolved Bone Phosphate."
15. "Harvest Queen Phosphate."
16. "Success Fertilizer."
17. "Lister's Special Corn Fertilizer."
18. "Lister's Vegetable Compound."
19. "Potato Manure Compound."
20. "Special Potato Fertilizer."

MAPES FORMULA AND PERUVIAN GUANO COMPANY, THE, No. 143 Liberty Street, New York.

1. "Mapes' Pure Ground Bone."
2. "Mapes' Complete Manure for General Use."
3. "Mapes' Tobacco Manure, Wrapper Brand."
4. "Mapes' Tobacco Starter Improved."
5. "Mapes' Complete 'A' Brand."
6. "Mapes' Corn Manure."
7. "Mapes' Grain Brand."
8. "Mapes' Cereal Brand."
9. "Mapes' General Crop Brand."
10. "Mapes' Cauliflower and Cabbage Manure."

11. "Mapes' Ammoniated Dissolved Bone with Potash."
12. "Mapes' Root and Fruit Brand."
13. "Mapes' Grass and Grain Spring Top Dressing."
14. "Mapes' Potato Manure."
15. "Mapes' Fruit and Vine Manure."
16. "Mapes' Economical Potato Manure."
17. "Mapes' Vegetable Manure or Complete Manure for all Crops."
18. "Mapes' Average Soil Complete Manure."

MARKEL, NOAH, Seitzland, Pa.

1. "Markel's Ammoniated Bone Phosphate."
2. "Markel's Potato Grower."
3. "Markel's Electric Phosphate."

**MARYLAND FERTILIZING AND MANUFACTURING COMPANY, No. 30, S.
Holliday Street, Baltimore, Md.**

1. "Sangston's Cereal and Plant Food."
2. "Alkaline Bone."
3. "Linden Super-Phosphate."
4. "Dissolved Phosphate."
5. "Dissolved South Carolina Bone."
6. "Special Compound for Potatoes."
6. "Special Compound for Potatoes and Tobacco."
7. "Ammoniated Bone."
8. "O. K. Ammoniated Bone."
9. "Bone Super-Phosphate."

MICHIGAN CARBON WORKS, Detroit, Mich.

1. "Homestead, A Bone Black Fertilizer."
2. "Desiccated Bone."
3. "Red Line Phosphate with Potash."
4. "Red Line Complete Manure."
5. "Red Line Crop Grower."
6. "General Crop Fertilizer."
7. "Red Line Phosphate."

MEHRING, FERDERICK, Bruceville, Md.

1. "Dissolved Raw Bone."
2. "\$26.00 Phosphate."
3. "Acid Phosphate."
4. "General Crop Producer."

MILLER FERTILIZER COMPANY, No. 411 East Pratt Street, Baltimore, Md.

1. "Harvest Queen Phosphate."
2. "Standard Phosphate."
3. "Special Potato Grower."
4. "W. G. Phosphate."
5. "Hustler Phosphate."
6. "Ammoniated Dissolved Bone."

MILSOM RENDERING AND FERTILIZER COMPANY, East Buffalo, N. Y.

1. "Buffalo Fertilizer."
2. "Vegetable Bone Fertilizer."
3. "Wheat, Oats and Barley Phosphate."
4. "Potato, Hop and Tobacco Phosphate."
5. "Buffalo Guano."
6. "Erie King."
7. "Corn Fertilizer."
8. "Dissolved Bone and Potash."
9. "Cyclone Pure Bone Meal."
10. "Pennsylvania Corn and Grain Grower."
11. "B. B. Guano."
12. "Acid Phosphate."

MORO-PHILLIPS CHEMICAL COMPANY, No. 131 S. Third Street, Philadelphia, Pa.

1. "Soluble Bone Phosphate."
2. "C. & G. Complete Fertilizer."
3. "Farmers' Phosphate."
4. "Alkaline Bone Phosphate."
5. "Special Fertilizer."
6. "Wheat Special."
7. "Pure Phosne."
8. "Standard Guano."
9. "Farmers' Potato Mixture."
10. "Steamed Bone."
11. "Fish Guano."
12. "No. 1 Potato Truck Manure."

MYERS, H. H., Codorus, Pa.

1. "Myers' Ammoniated Phosphate."
2. "Soluble Bone Phosphate."

McCALMONT & CO., Bellefonte, Pa.

1. "Champion \$25.00 Ammoniated Bone Super-Phosphate."
2. "Pure Dissolved High Grade South Carolina Bone Phosphate."
3. "McCalmont's High Grade Florida Bone Phosphate."

NELLER, AUGUSTUS, & CO., Stewartstown, Pa.

1. "Prolific Phosphate."
2. "Special Compound Phosphate."

NEWPORT, WM. C., COMPANY, Willow Grove, Pa.

1. "Newport's Rectified Phosphate."
2. "Newport's All Crop Fertilizer."
3. "Newport's Ammoniated Bone Phosphate."
4. "Newport's \$32.00 Brand."
5. "Newport's Ten Per Cent. Potash Phosphate."
6. "Newport's Pure Bone Dust."
7. "Newport's Special Fertilizer for Grass."
8. "Newport's Benefactor Phosphate."

NIAGARA FERTILIZER WORKS, P. O. Box 189, Buffalo, N. Y.

1. "Grain and Grass Grower."
2. "Potato, Tobacco and Hop."
3. "Triumph."
4. "Wheat and Corn Producer."
5. "Dissolved Bone Phosphate."
6. "Dissolved Bone and Potash."

OBER, G., & SON'S CO., No. 33 S. Gay Street, Baltimore, Md.

1. "Farmers' Standard Ammoniated Phosphate."
2. "Ober's Farmers' Mixture."
3. "Ober's Dissolved Bone Phosphate and Potash."
4. "Ober's Dissolved Bone Phosphate."
5. "Ober's Special Fertilizer for all Crops."

OHIO FARMERS' FERTILIZER COMPANY, Columbus, O.

1. "Acid Phosphate."
2. "Corn, Oats and Wheat Fish Guano."
3. "General Crop Fish Guano."
4. "Superior Phosphate."
5. "Improved Wheat Maker."
6. "Potato and Truck Fertilizer."

OSCEOLA FERTILIZER COMPANY, Osceola Mills, Pa.

1. "Pie Brand Pure Ground Bone."
2. "Ideal Manure."

OWENS, W. C., Philipsburg, Pa.

1. "Owen's Ammoniated Phosphate."

PACIFIC GUANO COMPANY, P. O. Box 2350, New York, N. Y.

1. "Nobsque Guano."
2. "Dissolved Bone Phosphate of Lime."
3. "A No. 1 Phosphate."
4. "Pacific Potato Phosphate."
5. "Pacific Dissolved Bone and Potash."
6. "Fine Ground Bone."

PACKERS' UNION FERTILIZER COMPANY, P. O. Box 1528, New York, N. Y.

1. Acidulated Bone."
2. "Universal Fertilizer."
3. "Wheat, Oats and Clover."
4. "American Wheat and Rye Grower."
5. "Banner Wheat Grower."
6. "Gardener's Complete Manure."
7. "Animal Corn Fertilizer."
8. "Potato Manure."

PATAPSCO GUANO COMPANY, P. O. Box 213, Baltimore, Md.

1. "Patapsco Special Wheat Compound."
2. "Grange Mixture."

3. "Patapsco Grain and Grass Producer."
4. "Coon Brand Guano."
5. "Patapsco Early Trucker."
6. "Sea Gull Guano."
7. "Patapsco Tobacco and Potato Fertilizer."
8. "Baltimore Soluble Phosphate."
9. "Patapsco Pure Dissolved South Carolina Bone."
10. "Patapsco Corn and Tomato Fertilizer."
11. "Patapsco High Grade Bone and Potash."
12. "Pure Ground Bone."
13. "Patapsco Soluble Bone and Potash."
14. "Patapsco Fish Guano."

PENNSYLVANIA AMMONIA AND FERTILIZER COMPANY, Harrisburg, Pa.

1. "Dauphin Brand."
2. "Capital Bone Super-Phosphate."
3. "Special Brand."
4. "Special Potato Vegetable Tobacco."
5. "Pure Ground Bone."
6. "Dissolved Bone and Potash."

PERKINS, A. W., & CO., Rutland, Vt.

1. Plantene."

PERKINS, J. DOUGLAS, Coatesville, Pa.

1. "Perkins' Ammoniated Bone Phosphate."
2. "Perkins' Celebrated Monarch, High Grade."
3. "Perkins' Globe Phosphate."
4. "Perkins' High Grade Acidulated Phosphate."
5. "Perkins' Special Bone Manure."

PIEDMONT MT. AIRY GUANO COMPANY, No. 109 Commerce Street, Baltimore, Md.

1. "Piedmont's Pure Raw Bone Mixture."
2. "Piedmont's High Grade South Carolina Bone."
3. "Clendennis Q. L. Ammoniated Phosphate (Quick and Lasting)."
4. "Clendennis T. & P. Super-Phosphate (Tried and Proved)."
5. "Piedmont's Farmers' High Grade Bone and Potash."
6. "Harvest King Ammoniated Bone."

PITTSBURG PROVISION COMPANY, Pittsburg, Pa.

1. "No. 1 Pure Raw Bone Meal."
2. "Pure Raw Bone Meal."
3. "Crescent Butchers' Ground Bone."
4. "Pure Bone with Potash."
5. "Corn and Potato Fertilizer."
6. "Keystone Fertilizer."
7. "Guano Fertilizer."
8. "Acid Fertilizer."

POLLOCK, R. H., No. 51 S. Gay Street, Baltimore, Md.

1. "Dissolved South Carolina Bone."
2. "Victor Bone Phosphate."
3. "Superior Corn and Tomato Fertilizer."
4. "Special Potato and Tobacco Fertilizer."
5. "Special Wheat Grower."
6. "Ammoniated Bone Phosphate."
7. "Soft Ground Bone."
8. "Owl Brand Guano."

PUGH & LYON, Oxford, Pa.

1. "Ground Raw Bone."
2. "Bone Phosphate."

QUINNIPIAC COMPANY, THE, No. 27 William Street, New York, N. Y.

1. "Quinnipiac Climax Phosphate."
2. "Quinnipiac Soluble Dissolved Bone."
3. "Quinnipiac Dissolved Bone and Potash."
4. "Quinnipiac Mohawk Fertilizer."
5. "Quinnipiac Uncas Bone Meal."
6. "Quinnipiac Special Potato."
7. "Corn Manure."
8. "Quinnipiac Ammoniated Dissolved Bone."

RAMSBERG FERTILIZER COMPANY, THE, Frederick, Md.

1. "Excelsior Plant Food."
2. "Old Virginia Compound."
3. "Ammoniated Bone Phosphate."
4. "Alkaline Phosphate."
5. "Desiccated Bone Super-Phosphate."

RASIN-MONUMENTAL COMPANY, No. 300 Water Street, Baltimore, Md.

1. "Empire Guano." (Rasin's.)
2. "Rasin's Dissolved Bone."
3. "Rasin's Ammoniated Alkaline Phosphate."
4. "Rasin's Bone and Potash Fertilizer."
5. "Rasin's IXL Fertilizer."
6. "Rasin's Ammoniated Super-Phosphate."
7. "Rasin's Acid Phosphate."
8. "Arundel Complete."
9. "Wm. Penn Crop Grower."
10. "Monumental Potato Manure."
11. "Monumental Soluble Bone Phosphate and Potash."
12. "Monumental Acid Phosphate."
13. "Sea Wall Special."
14. "Rasin's XXX Fertilizer."

RAUH, THE E., AND SONS FERTILIZER COMPANY, Indianapolis, Ind.

1. "Pure Ground Bone."
2. "Special Corn and Potato Fertilizer."
3. "Dissolved Bone and Potash."

4. "Soluble Bone."
5. "Acidulated Bone."

READING CHEMICAL AND FERTILIZER COMPANY, Reading, Pa.

1. "Potato Vegetable."
2. "Neversink Brand."
3. "A. A. Brand."
4. "Mt. Penn Brand."
5. "Reading Star."
6. "Dissolved Bone."
7. "Bone Meal."

READ FERTILIZER COMPANY, 100 Clinton Avenue, Syracuse, N. Y.

1. "Standard."
2. "Leader Blood and Bone."
3. "Acid Phosphate."
4. "Farmers' Friend."
5. "Vegetable, Vine and Potato."
6. "Alkaline Bone, or Bone and Potash."

RECKORD, THE HENRY, COMPANY, Bel-Air, Md.

1. "Special Compound."
2. "Animal Bone Phosphate."
3. "Dissolved South Carolina Bone."

REESE, JOHN S., Equitable Building, Baltimore, Md.

1. "Ammoniated Bone Phosphate Mixture."
2. "Reese's Challenge Crop Grower."
3. "Crown Phosphate and Potash."
4. "Dissolved Phosphate of Lime."
5. "Reese's Elm Phosphate."
6. "Reese's Grass and Grain."
7. "Reese's Half and Half."
8. "Reese's Harvest Queen."
9. "Reese's Mayflower."
10. "Potato and Truck Special."
11. "Reese's Special Wheat."
12. "Reese's Standard."
13. "Pilgrim."
14. "Potato Manure."
15. "High Grade Potash Mixture."

RICE, HAMPTON W., Lumberville, Pa.

1. "A. B. Phosphate." (W. Kenderdine's.)
2. "A. A. Phosphate." (W. Kenderdine's.)
3. "Potato Phosphate." (W. Kenderdine's.)

RICHEY, D. S., Uniontown, Pa.

1. "Pure Ground Bone."
2. "Bone Phosphate."
3. "Acid Phosphate."

RIVERSIDE ACID WORKS, Warren, Pa.

1. "Rich-acre Phosphate."
2. "Harvest Moon Phosphate."
3. "Old Gold Phosphate."
4. "Phosphoric and Potash."

ROBISON, ISAAC, Gay Street and Exchange Place, Baltimore, Md.

1. "Special Potato and Tomato Phosphate."
2. "Standard Dissolved Bone Phosphate."
3. "Special Wheat and Grass Phosphate."
4. "Potashed Bone."
5. "High Grade Soluble Phosphate."
6. "Pennsylvania Special Mixture."
7. "Fish, Rock and Potash."
8. "Peerless Phosphate."

RUSSELL & WHITEHEAD, Newark, N. J.

1. "A. D. Bone."
2. "Harvest Queen."
3. "Champion."
4. "Ground Bone."

SALE, GEO. T., Sandiford, Philadelphia, Pa.

1. "Special Manure for all Crops."

SCIENTIFIC FERTILIZER COMPANY, Pittsburg, Pa.

1. "Pure Raw Bone Meal."
2. "Scientific Potato."
3. "Scientific Economy."
4. "Acid Phosphate."
5. "Scientific Dissolved Bone."
6. "Scientific Corn and Grain."
7. "Scientific Bone, Meat and Potash."

SCOTT FERTILIZER COMPANY, Elkton, Md.

1. "Scott's Sure Growth Super-Phosphate."
2. "Scott's Standard Phosphate."
3. "Scott's Elk Head Super-Phosphate."
4. "Scott's Pure Ground Raw Bone."
5. "Scott's Tip Top Soluble Bone."
6. "Scott's Tip Top Soluble Bone and Potash."
7. "Scott's Potato Fertilizer No. 2."
8. "Scott's Sure Growth Compound."
9. "Scott's Potato Grower."
10. "Lancaster Tobacco Grower."

SHARPLESS & CARFENTER, No. 124 S. Delaware Avenue, Philadelphia, Pa.

1. "Acid Phosphate."
2. "Soluble Bone and Potash."
3. "No. 1 Bone Phosphate."

4. "Potato, Corn and Truck Guano."
5. "Gilt Edge Potato and Tobacco Manure."
6. "No. 2 for Grain and Grass."
7. "Royal Spring Mixture."
8. "Pure Bone Meal."
9. "Prairie Bone Meal."
10. "Dissolved Bone Phosphate for Potatoes and General Use."
11. "Evan's Potato Manure."
12. "Farmers' Bone Phosphate."
13. "Bone Meal."
14. "Kainit."

SCHALL-SHELDON FERTILIZER COMPANY, Erie, Pa.

1. "Sheldon's Empire."
2. "Sheldon's Farmers' Favorite."
3. "Sheldon's Truckers' Manure."
4. "Sheldon's Superior for all Crops."
5. "Pure Bone Meal."
6. "Dissolved Bone and Potash."
7. "Dissolved Bone."
8. "Dissolved Bone with Extra Potash."
9. "Sheldon's Grass, Grain and Potato."
10. "Sheldon's Guano."
11. "Schall's Corn and Potato Phosphate."
12. "Schall's Standard Phosphate."

SHENANDOAH FERTILIZER AND GARBAGE COMPANY, Shenandoah, Pa.

1. "Shenandoah Brand."
2. "Ringtown Clover."
3. "Golden Eagle."
4. "Pure Ground Bone."
5. "Special Wheat Grower."
6. "Standard Potato Fertilizer."
7. "N. & S. Complete Fertilizer."

SHOEMAKER, M. L., & CO., Port Richmond, Philadelphia, Pa.

1. "Swift Sure Super-Phosphate for General Use."
2. "Swift Sure Super-Phosphate for Potatoes."
3. "Swift Sure Bone Meal."
4. "Echo Super-Phosphate."
5. "Dissolved South Carolina Rock."
6. "Swift Sure Dissolved Bone."
7. "Good Enough Super-Phosphate."
8. "\$23.00 Super-Phosphate."
9. "Pure Raw Bone Meal."
10. "Swift Sure Super-Phosphate for Tobacco."
11. "Swift Sure Guano for Fall Trade."
12. "Swift Sure New Jersey Special Trade."

SICKLER, CHAS. A., & BRO., Wilkes-Barre, Pa.

1. "Special Manure for Potatoes and Tobacco."
2. "Empire Phosphate."
3. "Molarch Phosphate."
4. "Pure Ground Bone."

5. "Vegetable Vine."
6. "King Phosphate."

SIMONS, F. A., Maud P. O., Pa.

1. "Farmers' Favorite High Grade Phosphate (Truck and Corn)."
2. "Potato Grade."
3. "For General Use."

SLAGLE, E. A., Paxinos, Pa.

1. "Extra Bone Phosphate."
2. "Eclipse Plant Food."
3. "Quick Crop Grower."
4. "High Grade Acid Phosphate."

SMYSER, H. H., York, Pa.

1. "Chicago Soluble Bone."
2. "Chicago Crop Grower."
3. "Chicago Bone and Tankage."
4. "Chicago Bone and Potash."

SONDER, PETER, Morwood, Pa.

1. "Sonder's Fertilizer."

SOUTHERN FERTILIZER COMPANY, York, Pa.

1. "Queen of the Harvest."
2. "Dissolved Bone Phosphate."
3. "Farmers' Choice."
4. "Soluble Bone and Potash."
5. "Export Bone with Potash."
6. "Pure Ground Bone."
7. "Ammoniated Dissolved Bone."
8. "Special Potato Grower."
9. "General Crop Grower."
10. "Royal Wheat and Grass Grower."

STANDARD FERTILIZER COMPANY, No. 40 Exchange Place, New York, N. Y.

1. "Standard Guano."
2. "Standard A Brand."
3. "Standard Bone and Potash."
4. "Standard Ammoniated Dissolved Bone."
5. "Standard Dissolved Bone Phosphate."
6. "Standard Potato Grower."
7. "Standard Extra Fine Ground Bone."

STERNER, E. H., Codorus, Pa.

1. "Sterners' Dissolved Bone Phosphate."

STICK, H. S., Glenville, Pa.

1. "Stick's Dissolved South Carolina Bone."
2. "Peruvian Phosphate."
3. "York County Phosphate."

STRAINING, JOHN E., No. 1000 Cowden Street, Harrisburg, Pa.

1. "Meat and Bone Fertilizer."

STRAYER BROS., York, Pa.

1. "Strayer Bros. Wheat, Corn and Grass Grower."
2. "Strayer Bros. Bone and Potash Mixture."

STONER, E. B., Hellam, York County, Pa.

1. "Stoner's Wheat and Grass Fertilizer."

SUSQUEHANNA FERTILIZER COMPANY, Cor. South and Water Streets, Baltimore, Md.

1. "Susquehanna Bone Phosphate."
2. "Superior Rock Phosphate."
3. "Soluble Bone Phosphate."
4. "Ammoniated Bone Phosphate."
5. "XXV Phosphate."
6. "Alkaline Bone Phosphate."
7. "Potato Phosphate."
8. "Pure Ground Bone."
9. "Packing House Bone."
10. "High Grade Bone and Potash."
11. "Crop Grower."
12. "Soluble Bone and Potash."

SWIFT & CO., Chicago, Ill.

1. "Raw Bone Meal."
2. "Super-Phosphate."
3. "Complete Fertilizer."
4. "Diamond (S) Phosphate."
5. "Ammoniated Bone and Potash."
6. "Potato and Tobacco Grower."
7. "Bone Potash."
8. "Bone Meal."
9. "Bone Tankage."

TAYLOR PROVISION COMPANY, THE, Trenton, N. J.

1. "Special Potato Fertilizer."
2. "High Grade Corn and Truck Fertilizer."
3. "Pure Dissolved Bone and Potash."
4. "Ammoniated Dissolved Bone and Potash."
5. "High Grade Complete Fertilizer for Wheat and Grass."
6. "Pure Dissolved Bone."

TEMPLIN, J. M., Honeybrook, Pa.

1. "No. 5 High Grade Acid Phosphate."
2. "No. 8 High Grade Potash Manure."
3. "No. 4 Atlas Brand."
4. "No. 16 Cereal Fertilizer."
5. "No. 3 Farmers' Complete Fertilizer."

THOMAS, I. P., & SON CO., No. 2 S. Delaware Avenue, Philadelphia, Pa.

1. "Tip Top Raw Bone Super-Phosphate."
2. "Farmers' Choice Bone Phosphate."
3. "Improved Super-Phosphate."
4. "Normal Bone Phosphate."
5. "Special Corn Fertilizer."
6. "Alkaline Bone."
7. "Potato Fertilizer."
8. "Pure Ground Bone."
9. "Dissolved Phosphate."
10. "Special Alkaline Bone."
11. "South Carolina Phosphate."
12. "Champion Bone Phosphate."
13. "Raw and Dissolved Bone."

THOMAS, JAMES, Williamsport, Pa.

1. "Thomas' High Grade Potato and Tobacco Manure."
2. "Thomas' High Grade Bone Super-Phosphate."
3. "Thomas' Klondyke Ammoniated Phosphate."
4. "Thomas' Special Compound for Wheat, Oats, Corn and Grass."
5. "Thomas' Pure Dissolved South Carolina Bone."
6. "Pure Dissolved Soluble Bone and Potash Phosphate."
7. "Thomas' Standard Bone Phosphate."

TRENTON BONE FERTILIZER COMPANY, Trenton, N. J.

1. "\$32.00 Potato Fertilizer."
2. "Corn Mixture."
3. "Super-Phosphate."
4. "Potato Manure."

TRINLEY, JACOB, Linfield, Pa.

1. "Pure Raw Bone Meal."
2. "Pure Raw Bone Super-Phosphate."
3. "Grain and Grass Grower."
4. "Raven Bone Phosphate."

TUSCARORA FERTILIZER COMPANY, Port Royal, Pa.

1. "Ammoniated Tuscarora Phosphate."
2. "Pennsylvania Standard Phosphate."
3. "Big (4) Four."
4. "Acid Phosphate."
5. "Tuscarora Bone Phosphate."
6. "Bone and Potash."

TUSTIN, I. J., Phoenixville, Pa.

1. "Pickering Valley Special."
2. "Pickering Valley Special for Potatoes."
3. "Pickering Valley High Grade."

TYGERT-ALLEN FERTILIZER COMPANY, No. 2, Chestnut Street, Philadelphia, Pa.

1. "Allen's Nitro-Phosphate."
2. "Star Bone Phosphate."
3. "Allen's Alkaline Bone Phosphate."
4. "Standard Bone Phosphate."
5. "Allen's Popular Phosphate."
6. "Star Guano."
7. "Dissolved Bone Phosphate."
8. "Allen's Special Potato Manure."
9. "International Electric Guano."
10. "Star Soluble Bone and Potash."
11. "Allen's Peerless Potato Manure."
12. "Allen's Special for Wheat and Grass."
13. "Potato Fertilizer."
14. "Star Potato Grower."
15. "Walton & Whann's Reliance Ammoniated Super-Phosphate."
16. "Gold Edge Tobacco Manure."
17. "S. H. Howitz's Acid Phosphate."

TYGERT, J. E., COMPANY, No. 42 S. Delaware Avenue, Philadelphia, Pa.

1. "Bone Phosphate."
2. "Acid Phosphate."
3. "Potato Guano."
4. "Ammoniated Super-Phosphate."
5. "Golden Harvest Phosphate."
6. "Pure Ground Bone."
7. "Soluble Bone and Potash."
8. "Popular Phosphate."
9. "Victor Bone Fertilizer."

ULMER, JACOB, PACKING COMPANY, Pottsville, Pa.

1. "Blood, Bone and Meat Phosphate."

WAHL, EMIL, FANCY BONE MANUFACTURING COMPANY, Philadelphia, Pa.

1. "Warranted Pure Botton Bone Dust."

WALKER-STRATMAN COMPANY, Pittsburg, Pa.

1. "Meat, Blood and Bone with Potash."
2. "Pure Raw Bone Meal."
3. "Potato Special."
4. "Big Bonanza."
5. "Grain King."
6. "Four Fold."
7. "Help Mate."

WALKER, JOSEPH C., & SON, Gap, Pa.

1. "Pride of Pequea, High Grade."
2. "Pride of Pequea."

WALT, F. L. COMPANY, Supplee P. O., Pa.

1. "A. A. Acid Phosphate."
2. "Walt's XX Flesh Phosphate."
3. "Calsine Bone Super-Phosphate."

WALTON FERTILIZER COMPANY, THE, Cleveland, Ohio.

1. "Wheat and Grass Grower."
2. "Pure Bone and Potash."
3. "Special Dissolved Bone."
4. "German Truck and Potato Manure."
5. "Triumph Phosphate."

WAMBAUGH, LEVI, Parke P. O., Pa.

1. "Wambaugh's Mixture."

WHANN, W. E. WM., Penn P. O., Pa.

1. "Special Potato and Truck Fertilizer."
2. "Raw Bone Super-Phosphate."
3. "Fish and Potash Fertilizer."
4. "Ammoniated Super-Phosphate."
5. "No. 2 Ammoniated Super-Phosphate."
6. "Available Ammoniated Super-Phosphate."
7. "Special Ammoniated Super-Phosphate."
8. "Soluble Bone and Potash."
9. "South Carolina Phosphate."
10. "Pure Ground Bone."
11. "Whann's Celery Mixture."

WHEELER, M. E., & CO., Rutland, Vt.

1. "Superior Truck Fertilizer."
2. "Havana Tobacco Grower."
3. "Potato Fertilizer."
4. "Corn Fertilizer."
5. "Royal Wheat Grower."
6. "Grass and Oats."
7. "Wheat and Clover."
8. "Electrical Dissolved Bone."
9. "High Grade Fruit Fertilizer."
10. "Pure Bone."

**WILLIAMS AND CLARK FERTILIZER COMPANY, No. 27 William Street,
New York, N. Y.**

1. "Americus Universal Ammoniated Dissolved Bone."
2. "Americus Royal Bone Phosphate."
3. "Americus Prolific Crop Producer."
4. "Americus Good Grower Potato Phosphate."
5. "Americus Dissolved Bone and Potash."
6. "Americus Acorn Brand."
7. "Pure Bone Meal."
8. "Americus Cartaret Ground Bone."
9. "Americus High Grade Special."

WINDLE, DOAN & CO., Coatesville, Pa.

1. "Ground Bone."
2. "Cook's Bone Phosphate."
3. "Ammoniated Bone Phosphate."

WOOLDRIDGE COMPANY, THE R. A., No. 33 S. Gay Street, Baltimore, Md.

1. "Florida Acid Phosphate."
2. "Liberty Bell Potash Mixture."
3. "Champion Giant."
4. "Chieftain Phosphate."
5. "Triumph Pure Bone Phosphate."
6. "Tuckahoe Raw Bone Meal."
7. "Special Potato Fertilizer."
8. "Old Sledge Phosphate."
9. "Bone and Potash."
10. "Buffalo Dissolved Bone Phosphate."

WORRELL, ISAAC L., Worrell P. O., Pa.

1. "Ground Bone."

YORK CHEMICAL WORKS, York, Pa.

1. "Black Cross Phosphate."
2. "Red Cross Phosphate."
3. "New York Phosphate."
4. "Prosperity Ammoniated Bone and Potash Phosphate."
5. "Pure Ammoniated Raw Bone Phosphate."
6. "Pure Ground Raw Bone."
7. "Dissolved Phosphate."

ZELL GUANO COMPANY, THE, No. 32 South Street, Baltimore, Md.

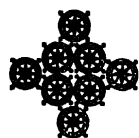
1. "Zell's Special Compound for Potatoes, Vegetables, Etc."
2. "Zell's Pure Dissolved Animal Bone."
3. "Zell's Ammoniated Bone Super-Phosphate."
4. "Zell's Economizer Phosphate."
5. "The Little Giant."
6. "Zell's Hustler Phosphate."
7. "Zell's Electric Phosphate."
8. "Zell's Dissolved Bone Phosphate and Potash."
9. "Zell's Dissolved Bone Phosphate."
10. "Zell's Dissolved South Carolina Phosphate."

ZIEGLER, E. H., & CO., Stewartstown, Pa.

1. "Bone Phosphate."
2. "Ziegler's Potato Phosphate."
3. "Ziegler's Mixture."
4. "Ziegler's Crop Grower."

ZOOK, HENRY S., Blue Rock, Pa.

1. "Pride of Chester Dissolved Animal Bone Phosphate for General Use."
2. "Pride of Chester Corn, Oats and Wheat Phosphate."
3. "Pride of Chester Animal Bone Phosphate."



APPENDIX.



APPENDIX.

LIST OF PUBLICATIONS OF THE PENNSYLVANIA DEPARTMENT OF AGRICULTURE.

ANNUAL REPORTS.

- *Report of the State Board of Agriculture, 336 pages, 1877.
- *Report of the State Board of Agriculture, 625 pages, 1878.
- *Report of the State Board of Agriculture, 560 pages, 1879.
- *Report of the State Board of Agriculture, 557 pages, 1880.
- *Report of the State Board of Agriculture, 646 pages, 1881.
- *Report of the State Board of Agriculture, 645 pages, 1882.
- *Report of the State Board of Agriculture, 645 pages, 1883.
- *Report of the State Board of Agriculture, 648 pages, 1884.
- *Report of the State Board of Agriculture, 645 pages, 1885.
- *Report of the State Board of Agriculture, 646 pages, 1886.
- *Report of the State Board of Agriculture, 650 pages, 1887.
- *Report of the State Board of Agriculture, 648 pages, 1888.
- *Report of the State Board of Agriculture, 650 pages, 1889.
- *Report of the State Board of Agriculture, 594 pages, 1890.
- *Report of the State Board of Agriculture, 600 pages, 1891.
- *Report of the State Board of Agriculture, 604 pages, 1892.
- *Report of the State Board of Agriculture, 713 pages, 1893.
- *Report of the State Board of Agriculture, 646 pages, 1894.
- *Report of the Department of Agriculture, 878 pages, 1895.
- Report of the Department of Agriculture, Part 1, 820 pages, 1896.
- Report of the Department of Agriculture, Part 2, 444 pages, 1896.
- *Report of the Department of Agriculture, Part 1, 897 pages, 1897.
- *Report of the Department of Agriculture, Part 2, 309 pages, 1897.
- Report of the Department of Agriculture, 894 pages, 1898.
- Report of the Department of Agriculture, Part 1, 1082 pages, 1899.
- Report of the Department of Agriculture, Part 2, 368 pages, 1899.
- Report of the Department of Agriculture, Part 1, 1010 pages, 1900.
- Report of the Department of Agriculture, Part 2, — pages, 1900.

*Note.—Edition exhausted.

BULLETINS.

No. 1.* Tabulated Analyses of Commercial Fertilizers, 24 pages, 1895.

No. 2.* List of Lecturers of Farmers' Institutes, 36 pages, 1895.

No. 3.* The Pure Food Question in Pennsylvania, 38 pages, 1895.

No. 4.* Tabulated Analyses of Commercial Fertilizers, 22 pages, 1896.

No. 5.* Tabulated Analyses of Commercial Fertilizers, 38 pages, 1896.

No. 6.* Taxidermy; How to Collect Skins, etc., 128 pages, 1896.

No. 7.* List of Creameries in Pennsylvania, 68 pages, 1896.

No. 8.* Report of State Horticultural Association, 108 pages, 1896.

No. 9.* Report of Dairymen's Association, 96 pages, 1896.

No. 10.* Prepared Food for Invalids and Infants, 12 pages, 1896.

No. 11.* Tabulated Analyses of Commercial Fertilizers, 22 pages, 1896.

No. 12.* Road Laws for Pennsylvania, 42 pages, 1896.

No. 13.* Report of Butter Colors, 8 pages, 1896.

No. 14.* Farmers' Institutes in Pennsylvania, 92 pages, 1896.

No. 15. Good Roads for Pennsylvania, 42 pages, 1896.

No. 16. Dairy Feeding as Practiced in Pennsylvania, 126 pages, 1896.

No. 17.* Diseases and Enemies of Poultry, 128 pages, 1896.

No. 18.* Digest of the General and Special Road Laws for Pennsylvania, 130 pages, 1896.

No. 19. Tabulated Analyses of Commercial Fertilizers, 40 pages, 1896.

No. 20.* Preliminary Report of Secretary, 126 pages, 1896.

No. 21. The Township High School, 24 pages, 1897.

No. 22.* Cider Vinegar of Pennsylvania, 28 pages, 1897.

No. 23.* Tabulated Analyses of Commercial Fertilizers, 31 pages, 1897.

No. 24.* Pure Food and Dairy Laws of Pennsylvania, 19 pages, 1897.

No. 25.* Farmers' Institutes in Pennsylvania, 8 pages, 1897.

No. 26. Farmers' Institutes in Pennsylvania, 74 pages, 1897.

No. 27. The Cultivation of American Ginseng, 23 pages, 1897.

No. 28. The Fungous Foes of the Farmer, 19 pages, 1897.

No. 29. Investigations in the Bark of the Tree, 17 pages, 1897.

- No. 30. Sex in Plants, 17 pages, 1897.
- No. 31. The Economic Side of the Mole, 42 pages, 1898.
- No. 32.* Pure Food and Dairy Laws, 30 pages, 1898.
- No. 33.* Tabulated Analyses of Commercial Fertilizers, 42 pages, 1898.
- No. 34.* Preliminary Report of the Secretary, 150 pages, 1898.
- No. 35. Veterinary Medicines, 23 pages, 1898.
- No. 36.* Constitutions and By-Laws, 72 pages, 1898.
- No. 37.* Tabulated Analyses of Commercial Fertilizers, 40 pages, 1898.
- No. 38.* Farmers' Institutes in Pennsylvania, 8 pages, 1898.
- No. 39.* Farmers' Institutes in Pennsylvania, 88 pages, 1898.
- No. 40. Questions and Answers, 206 pages, 1898.
- No. 41. Preliminary Reports of the Department, 189 pages, 1899.
- No. 42.* List of Creameries in Pennsylvania, 88 pages, 1899.
- No. 43. The San José Scale and other Scale Insects, 22 pages, 1899.
- No. 44. Tabulated Analyses of Commercial Fertilizers, 62 pages, 1899.
- No. 45. Some Harmful Household Insects, 13 pages, 1899.
- No. 46. Some Insects Injurious to Wheat, 24 pages, 1899.
- No. 47. Some Insects Attacking Fruit, etc., 19 pages, 1899.
- No. 48. Common Cabbage Insects, 14 pages, 1899.
- No. 49. Method of Protecting Crops, etc., 20 pages, 1899.
- No. 50. Pure Food and Dairy Laws of Pennsylvania, 33 pages, 1899.
- No. 51. Tabulated Analyses of Commercial Fertilizers, 69 pages, 1899.
- No. 52.* Proceedings Spring Meeting of Board of Agriculture, 296 pages, 1899.
- No. 53. Farmers' Institutes in Pennsylvania, 1899-1900, 94 pages, 1899.
- No. 54. Tabulated Analyses of Commercial Fertilizers, 163 pages, 1899.
- No. 55. The Composition and Use of Fertilizers, 126 pages, 1899.
- No. 56. Nursery Fumigation and the Construction and Management of the Fumigating House, 24 pages, 1899.
- No. 57. The Application of Acetylene Illumination to Country Homes, 85 pages, 1899.
- No. 58. The Chemical Study of the Apple and Its Products, 44 pages, 1899.
- No. 59. Fungous Foes of Vegetable Fruits, 39 pages, 1899.
- No. 60. List of Creameries in Pennsylvania, 33 pages, 1899.
- No. 61. The Use of Lime on Pennsylvania Soils, 170 pages, 1900.

No. 62. A Summer's Work Abroad in School Grounds, Home Grounds, Play Grounds, Parks and Forests, 34 pages, 1900.

No. 63. A Course in Nature Study for Use in the Public Schools, 119 pages, 1900.

No. 64. Nature Study Reference Library for Use in the Public Schools, 22 pages, 1900.

No. 65. Farmers' Library List, 29 pages, 1900.

No. 66. Pennsylvania Road Statistics, 98 pages, 1900.

No. 67. Methods of Steer Feeding, 14 pages, 1900.

No. 68. Farmers' Institutes in Pennsylvania, 90 pages, 1900.

No. 69. Road Making Materials of Pennsylvania, 104 pages, 1900.

No. 70. Tabulated Analyses of Commercial Fertilizers, 97 pages, 1900.

No. 71. Consolidation of Country Schools and the Transportation of the Scholars by Use of Vans, 89 pages, 1900.

No. 72. Tabulated Analyses of Commercial Fertilizers, 170 pages, 1900.

*Note.—Edition exhausted.

CROP REPORT FOR 1900.

Giving Prices of Farm Products and Live Stock, with Farm Wages and Board, in Pennsylvania by Counties. Collected by A. L. Martin, Deputy Secretary of Agriculture.

Counties.	Prices of Farm Products and Live Stock								
	Wheat, per bushel.	Corn, per bushel (shelled).	Corn, per bushel (in the ear).	Oats, per bushel (old).	Oats, per bushel (new).	Potatoes, per bushel (new).	Hay, clover, per ton (old).	Hay clover, per ton (new).	Hay, timothy, per ton (old).
Adams,	\$0.68	\$0.47	\$0.42	\$0.37	\$0.30	\$0.64	\$11.00	\$12.00	\$15.00
Allegheny, .....	.72	.50	.48	.30	.29	.55	.....	13.00	.....
Armstrong, .....	.70	.47	.47	.30	.27	.50	10.00	9.00	13.00
Beaver, .....	.73	.46	.36	.31	.30	.58	.....	11.33	12.00
Bedford, .....	.73	.47	.33	.27	.25	.38	8.00	6.68	9.00
Berks, .....	.72	.43	.40	.36	.32	.53	12.00	10.66	16.00
Blair, .....	.75	.57	.56	.35	.28	.57	12.00	9.00	15.00
Bradford, .....	.78	.50	.50	.31	.32	.80	10.00	10.00	15.00
Bucks, .....	.70	.40	.40	.32	.30	.50	.....	10.00	14.00
Butler, .....	.76	.46	.50	.35	.29	.49	10.00	9.30	14.50
Cambria, .....	.80	.51	.41	.35	.36	.68	10.00	13.00	16.00
Cameron, .....	.82	.53	.56	.40	.38	.63	12.00	12.00	15.50
Carbon, .....	.74	.47	.48	.37	.31	.55	11.20	11.30	17.00
Centre, .....	.70	.52	.45	.32	.30	.45	9.00	10.00	13.00
Chester, .....	.70	.41	.38	.37	.28	.52	10.35	9.60	13.50
Clarion, .....	.68	.49	.34	.30	.26	.43	8.50	9.00	12.00
Clearfield, .....	.77	.55	.50	.38	.33	.60	11.00	12.00	14.50
Clinton, .....	.70	.50	.43	.35	.28	.55	14.60	12.00	16.00
Columbia, .....	.73	.50	.41	.29	.25	.50	10.00	12.00	12.00
Crawford, .....	.79	.48	.46	.32	.27	.35	7.66	8.66	10.00
Cumberland, .....	.67	.43	.40	.29	.28	.63	11.00	12.25	15.50
Dauphin, .....	.68	.49	.41	.33	.30	.68	10.68	11.33	15.00
Delaware, .....	.72	.50	.40	.35	.....	.....	13.00	.....	17.00
Elk, .....	.78	.52	.....	.34	.35	.60	16.00	15.50	16.00
Erie, .....	.75	.45	.50	.32	.26	.33	10.00	9.00	14.00
Fayette, .....	.68	.....	.56	.30	.23	.60	.....	13.50	.....
Forest, .....	.77	.45	.48	.38	.33	.45	14.50	12.30	17.00
Franklin, .....	.69	.50	.34	.34	.32	.55	7.50	8.50	12.00
Fulton, .....	.63	.55	.33	.30	.25	.62	11.00	11.50	11.25
Greene, .....	.70	.34	.53	.30	.26	.45	10.00	10.00	11.30
Huntingdon, .....	.73	.47	.47	.30	.27	.65	.....	14.00	16.00
Indiana, .....	.70	.49	.48	.34	.29	.46	8.50	9.00	11.00
Jefferson, .....	.95	.58	.50	.36	.33	.50	12.00	12.00	16.00
Juniata, .....	.69	.52	.48	.31	.31	.58	11.00	12.50	14.50
Lackawanna, .....	.85	.50	.46	.35	.32	.64	.....	13.30	18.00
Lancaster, .....	.67	.47	.47	.29	.28	.60	9.30	11.60	14.00
Lawrence, .....	.76	.49	.38	.30	.25	.47	9.00	9.30	11.70
Lebanon, .....	.69	.47	.50	.31	.25	.63	13.00	13.00	15.00
Lehigh, .....	.70	.47	.34	.32	.29	.51	13.30	12.50	15.00
Luzerne, .....	.79	.52	.54	.32	.32	.58	12.00	12.30	17.00
Lycoming, .....	.76	.48	.42	.34	.28	.63	14.00	14.00	16.00
McKean, .....	.....	.50	.50	.....	.30	.50	10.00	.....	.....
Mercer, .....	.75	.34	.36	.29	.25	.31	8.00	8.00	10.30
Mifflin, .....	.68	.50	.45	.33	.28	.68	13.50	12.00	15.00
Monroe, .....	.72	.49	.35	.34	.31	.60	14.00	15.00	18.00
Montgomery, .....	.68	.49	.50	.35	.30	.65	.....	11.00	15.00
Montour, .....	.69	.45	.47	.29	.24	.63	12.00	10.00	13.00
Northampton, .....	.75	.50	.45	.33	.29	.55	12.50	10.00	16.00
Northumberland, .....	.71	.42	.50	.28	.28	.55	10.66	11.50	15.30
Perry, .....	.69	.48	.43	.28	.27	.59	11.00	11.75	13.75
Philadelphia, .....	.79	.52	.....	.31	.....	.80	.....	15.00	.....
Pike, .....	.77	.53	.53	.30	.36	.60	13.30	14.00	14.00
Potter, .....	.....	.56	.50	.34	.31	.41	9.00	9.50	10.00
Schuylkill, .....	.76	.50	.....	.34	.33	.50	11.00	12.00	13.00
Snyder, .....	.72	.48	.46	.30	.27	.50	10.00	10.00	13.00
Somerset, .....	.70	.47	.45	.34	.29	.40	9.00	8.00	11.00
Sullivan, .....	.80	.49	.48	.36	.33	.54	10.00	10.00	12.00
Susquehanna, .....	.87	.44	.50	.35	.31	.54	14.00	14.00	11.30
Tioga, .....	.80	.49	.46	.32	.31	.53	10.25	10.25	10.25
Union, .....	.73	.50	.50	.29	.28	.45	10.00	11.00	11.00
Venango, .....	.83	.50	.50	.33	.29	.45	13.00	11.00	12.00
Warren, .....	.82	.43	.40	.34	.30	.44	8.00	10.00	9.50
Washington, .....	.69	.54	.50	.32	.30	.53	9.00	11.00	11.00
Wayne, .....	.83	.50	.....	.32	.33	.57	.....	11.00	.....
Westmoreland, .....	.69	.45	.46	.32	.25	.50	13.00	13.50	13.70
Wyoming, .....	.73	.46	.48	.34	.31	.50	.....	10.60	14.00
York, .....	.69	.44	.55	.28	.28	.63	9.00	9.00	12.00
Average,	\$0.73.3	\$0.48.2	\$0.45.4	\$0.32.6	\$0.29.4	\$0.53.9	\$10.98	\$11.20	\$13.85

CROP REPORT FOR 1900—Continued.

Counties.	Prices of Farm Products and Live Stock.									
	Hay, timothy, per ton (new).	Butter, per pound (average), at store.	Butter, per pound (average), in market.	Ewes (average), per head.	Lambs (average), per head.	Horses (average), per head.	Mules (average), per head.	Cows (average), per head.	Chickens (dressed), per pound.	Chickens (live), per pound.
Adams,	\$15.25	\$0.17	\$0.20	\$2.50	\$3.30	\$70.00	\$95.00	\$33.00	\$0.11	\$0.08
Allegheny,	15.00	.20	.20	4.00	3.00	77.00	.....	42.50	.14	.11
Armstrong,	11.40	.21	.23	3.25	3.12	80.00	70.00	32.00	.11	.08
Beaver,	13.30	.23	.25	3.16	2.16	100.00	.....	34.00	.12	.08
Bedford,	9.23	.18	.21	3.50	3.00	75.00	.....	32.00	.08	.07
Berks,	13.50	.21	.23	.....	.....	82.00	80.00	35.00	.12	.08
Blair,	10.00	.23	.25	4.25	4.25	75.00	100.00	35.00	.15	.10
Bradford,	13.00	.18	.20	2.50	3.50	75.00	.....	21.00	.12	.08
Bucks,	12.00	.25	.25	4.00	4.00	100.00	100.00	40.00	.12	.10
Butler,	13.00	.18	.23	2.75	3.00	80.00	75.00	32.50	.10	.08
Cambria,	15.25	.22	.25	3.33	2.66	97.50	.....	33.20	.14	.10
Cameron,	16.35	.24	.24	3.50	2.75	103.00	.....	30.00	.14	.09
Carbon,	14.50	.23	.26	.....	.....	106.00	125.00	35.00	.12	.10
Centre,	13.00	.18	.24	3.00	4.00	80.00	.....	28.00	.12	.08
Chester,	12.00	.20	.26	4.25	4.92	112.00	105.00	46.00	.12	.10
Clarion,	10.50	.18	.22	3.25	3.00	100.00	90.00	28.00	.11	.07
Clearfield,	13.00	.24	.26	2.25	2.30	100.00	125.00	30.00	.12	.07
Clinton,	15.00	.18	.21	3.80	3.50	75.00	80.00	30.00	.12	.08
Columbia,	13.75	.23	.24	3.75	3.63	100.00	100.00	30.00	.13	.08
Crawford,	9.75	.18	.21	3.12	3.12	77.50	.....	32.00	.11	.07
Cumberland,	15.83	.21	.22	4.50	4.00	73.00	71.25	33.00	.13	.09
Dauphin,	15.75	.20	.22	.....	.....	83.00	95.00	36.00	.10	.08
Delaware, .....	.....	.25	.....	.....	.....	.....	.....	55.00	.18	.12
Elk,	16.50	.20	.20	4.00	3.00	82.00	.....	32.50	.15	.11
Erie,	11.50	.20	.22	4.50	3.40	85.00	100.00	32.00	.12	.08
Fayette,	14.50	.19	.22	4.00	3.00	120.00	.....	35.00	.11	.07
Forest,	13.30	.22	.22	3.75	2.75	88.00	70.00	35.00	.13	.08
Franklin,	12.00	.18	.21	6.00	3.68	82.00	77.50	29.30	.13	.08
Fulton,	14.25	.16	.18	4.50	3.25	73.00	70.00	25.00	.....	.....
Greene,	12.00	.16	.18	3.33	2.00	108.00	70.00	33.00	.11	.07
Huntingdon,	15.50	.26	.25	4.50	3.50	74.00	80.00	25.00	.....	.09
Indiana,	11.60	.19	.21	3.41	3.05	76.00	88.00	33.00	.11	.08
Jefferson,	15.50	.19	.20	3.50	2.62	85.00	90.00	29.00	.11	.08
Juniata,	15.00	.20	.21	3.83	3.00	65.00	60.00	33.00	.09	.07
Lackawanna,	16.25	.22	.22	3.50	3.00	100.00	100.00	30.00	.14	.12
Lancaster,	13.30	.18	.21	3.00	3.25	75.00	83.20	36.60	.10	.08
Lawrence,	14.20	.20	.24	3.83	3.10	80.00	100.00	35.00	.11	.08
Lebanon,	15.30	.19	.20	5.00	3.00	95.00	90.00	41.00	.12	.09
Lehigh,	15.25	.18	.22	3.00	3.00	90.00	92.00	32.00	.11	.09
Luzerne,	17.00	.19	.22	4.75	3.50	118.00	150.00	35.00	.12	.10
Lycoming,	17.50	.23	.25	3.00	3.50	100.00	.....	27.00	.13	.08
McKean,	13.00	.23	.....	2.00	2.00	100.00	.....	33.00	.10	.09
Mercer,	9.50	.17	.21	2.80	2.75	80.00	.....	30.00	.11	.07
Mifflin,	14.60	.19	.24	3.43	3.18	94.00	86.60	33.00	.10	.08
Monroe,	16.00	.20	.24	3.00	3.75	93.00	.....	34.00	.12	.10
Montgomery,	12.00	.27	.28	4.50	4.00	80.00	100.00	40.00	.14	.11
Montour,	12.60	.20	.25	4.00	3.15	68.00	.....	28.00	.14	.10
Northampton,	14.00	.23	.26	2.50	3.50	100.00	100.00	37.00	.10	.08
Northumberland,	15.75	.20	.27	4.00	3.40	75.00	85.00	32.00	.12	.08
Perry,	14.00	.15	.19	3.16	2.75	95.00	87.00	30.00	.10	.08
Philadelphia,	14.50	.27	.28	3.00	5.00	.....	.....	45.00	.15	.13
Pike,	12.00	.21	.22	3.63	4.00	95.00	77.00	33.00	.12	.10
Potter,	11.50	.19	.22	2.75	3.00	70.00	.....	24.00	.09	.07
Schuykill,	15.00	.16	.22	.....	.....	75.00	100.00	35.00	.15	.10
Snyder,	13.00	.17	.19	5.00	3.00	80.00	85.00	34.00	.10	.07
Somerset,	11.00	.17	.20	3.00	3.00	93.00	150.00	35.00	.10	.08
Sullivan,	13.50	.18	.21	4.00	3.70	87.00	80.00	30.00	.12	.10
Susquehanna,	11.50	.25	.23	3.00	3.00	80.00	.....	30.00	.11	.08
Tioga,	14.25	.21	.20	3.00	2.80	75.00	.....	20.00	.11	.08
Union,	12.00	.19	.21	4.00	3.25	90.00	92.50	37.50	.12	.08
Venango,	11.50	.23	.21	3.50	3.10	85.00	70.00	30.00	.12	.09
Warren,	13.00	.23	.20	3.25	3.25	120.00	.....	33.00	.12	.10
Washington,	12.50	.21	.25	4.00	2.75	93.00	100.00	33.00	.13	.10
Wayne,	14.00	.25	.22	4.00	3.75	95.00	100.00	30.00	.13	.09
Westmoreland,	16.00	.24	.19	4.00	3.75	105.00	100.00	35.00	.11	.09
Wyoming,	13.00	.21	.22	3.00	3.00	83.00	110.00	25.00	.10	.08
York,	13.00	.17	.18	4.50	4.25	60.00	75.00	32.00	.10	.08
Average,	\$13.58	\$0.20.4	\$0.22.4	\$3.61	\$3.26	\$87.61	\$92.06	\$33.08	\$0.11.9	\$0.08.7

CROP REPORT FOR 1900—Continued.

Counties.	Prices of Farm Products and Live Stock.					
	Farm land (well improv- ed).	Farm land (average).	Short wool (unwashed).	Short wool (washed).	Middle wool (unwashed).	Middle wool (washed).
Adams,	\$57.00	\$37.00	\$0.15	\$0.20	\$0.19	\$0.20
Allegheny,	150.00	73.00				
Armstrong,	62.00	35.00	.20	.26		
Beaver,	60.00	30.00	.19	.24	.23	.27
Bedford,	62.00	30.00				
Berks,	75.00	40.00				
Blair,	80.00	45.00	.18		.18	
Bradford,	30.00	20.00	.20	.26	.24	.30
Bucks,	60.00	50.00				
Butler,	45.00	25.00	.16	.21	.18	.22
Cambria,	50.00	35.00	.18		.18	
Cameron,	40.00	20.00	.20	.24	.28	.23
Carbon,	40.00	25.00				
Centre,	62.00	40.00				.23
Chester,	60.00	55.00	.21		.21	
Clarion,	32.00	24.00	.16	.24	.16	.24
Clearfield,	43.00	26.00	.19	.23	.23	.30
Clinton,	53.00	33.00	.20	.30	.20	.30
Columbia,	35.00	21.00			.20	.30
Crawford,	50.00	23.00			.19	.30
Cumberland,	100.00	50.00	.20	.25		.18
Dauphin,	58.00	38.00	.13	.18	.15	.18
Delaware,	80.00	90.00	.21		.21	
Elk,	30.00	15.00				
Erie,	85.00	40.00			.20	.30
Fayette,	80.00	55.00	.18	.23	.20	.25
Forest,	33.00	18.00	.27	.26	.22	.24
Franklin,	100.00	50.00	.20	.25	.15	.22
Fulton,	37.00	23.00				.20
Greene,	53.00	43.00	.20	.26		
Huntingdon,	38.00	37.00	.18		.20	.30
Indiana,	45.00	28.00	.17			
Jefferson,	40.00	25.00	.18	.27	.18	.27
Juniata,	47.00	42.00			.17	
Lackawanna,	63.00	40.00	.23	.25	.25	.26
Lancaster,	87.00	63.00	.18	.25	.17	.18
Lawrence,	50.00	40.00	.17	.21	.20	.25
Lebanon,	100.00	75.00				
Lehigh,	54.00	35.00	.15	.25	.30	.45
Luzerne,	38.00	45.00				
Lycoming,	50.00	30.00	.20	.22	.19	.20
McKean,	30.00	20.00	.21	.30	.22	
Mercer,	55.00	33.00	.18	.23	.20	.25
Mifflin,	75.00	65.00			.20	.30
Monroe,	35.00	15.00				
Montgomery,	75.00	65.00				
Montour,	50.00	20.00				
Northampton,	100.00	75.00			.19	.22
Northumberland,	50.00	30.00				
Perry,	45.00	25.00	.15	.20	.16	.14
Philadelphia,	200.00	140.00				
Pike,	53.00	23.00				
Potter,	47.00	24.00	.20	.25	.22	.22
Schuylkill,	45.00	29.00			.18	
Snyder,	55.00	33.00	.15	.20	.18	.22
Somerset,	64.00	45.00	.21	.23		
Sullivan,	50.00	40.00	.21	.26		
Susquehanna,	25.00	17.00	.20	.25	.21	.26
Tioga,	30.00	25.00	.20	.26	.20	
Union,	88.00	45.00	.20	.30	.22	.30
Venango,	30.00	20.00	.20	.25	.23	
Warren,	33.00	21.00	.20	.25	.19	.23
Washington,	85.00	61.00	.20	.25	.20	.28
Wayne,	30.00	20.00			.22	
Westmoreland,	90.00	60.00				
Wyoming,	40.00	23.00	.22	.29	.20	
York,	50.00	25.00				
Average,	\$60.00	\$38.00	\$0.19	\$0.25	\$0.20	\$0.24

CROP REPORT FOR 1900—Continued.

Counties.	Prices of Farm Products and Live Stock.						
	Long wool (unwashed).	Long wool (washed).	Swine, shoats, per pound.	Fat hogs, per pound.	Steers for feeding.	Steers, fat.	Milk, per 100 pounds (wholesale).
Adams,	\$0.22	\$0.25	\$0.05	\$0.06	\$0.95	\$4.50	\$0.93
Allegheny, .....			.04	.05			1.40
Armstrong, .....			.05	.05			
Beaver, .....	.24	.29	.04	.05	4.00	5.00	1.05
Bedford, .....	.20	.30	.04	.06	3.50	6.00	
Berks, .....			.04	.07	4.25	5.00	1.10
Blair, .....			.08	.06			1.12
Bradford, .....	.22	.28	.04	.04			1.30
Bucks,							1.75
Butler, .....	.15	.22	.07	.05			1.00
Cambria, .....	.20	.26	.04	.05			1.00
Cameron, .....	.20	.29	.04	.06	3.50	4.50	.95
Carbon,							
Centre, .....			.04	.05	3.50	4.50	.85
Chester, .....	.21		.05	.06			1.00
Clarion, .....	.16	.24	.06	.05			1.00
Clearfield, .....	.19	.28	.05	.06	3.40	4.40	1.00
Clinton, .....	.20	.30	.04	.05			1.00
Columbia, .....			.06	.05			
Crawford, .....	.21	.30	.05	.06			.84
Cumberland, .....	.25	.40	.07	.6			.95
Dauphin, .....	.18	.22	.06	.05			1.15
Delaware, .....	.21		.05	.06			1.00
Elk, .....	.21	.30		.06			.85
Erie, .....			.04	.05	3.00	3.75	1.25
Fayette, .....	.21	.25	.05	.05			2.00
Forest, .....	.25	.27	.04	.05			2.00
Franklin, .....			.05	.06	4.00	4.75	1.00
Fulton, .....			.04	.05			.90
Greene, .....		.28	.05	.04	3.50	3.75	2.00
Huntingdon, .....			.08	.06			1.10
Indiana, .....	.20	.26	.04	.05			
Jefferson, .....	.18	.27	.04	.04			
Juniata, .....			.05	.06			
Lackawanna, .....	.25	.30	.07	.07			1.85
Lancaster, .....	.14	.18	.05	.06	4.50	5.00	.95
Lawrence, .....	.20	.25					1.50
Lebanon, .....			.10	.07			1.10
Lehigh, .....	.30	.45	.09	.06	3.50	4.50	.92
Luzerne, .....			.05	.06	3.00	4.00	
Lycoming, .....	.18	.20	.05	.05	2.75	4.50	.87
McKean, .....	.22				3.00	4.00	
Mercer, .....	.21	.24	.04	.04	3.50	4.10	
Mifflin, .....			.05	.05	4.30	4.50	1.50
Monroe, .....			.06	.06			1.33
Montgomery, .....			.06	.07	3.50		1.10
Montour, .....			.05	.06			1.50
Northampton, .....			.05	.07	4.50	5.50	1.25
Northumberland, .....			.05	.04	4.25	5.25	
Perry, .....	.20	.26	.05	.04	3.50	4.50	1.25
Philadelphia, .....			.07	.06	4.50	5.50	1.12
Pike, .....	.20	.28	.06	.05			
Potter, .....			.04	.06	3.50	4.50	1.15
Schuylkill, .....			.08	.07			1.00
Snyder, .....	.10	.15	.05	.06	3.75	4.50	1.75
Somerset, .....			.06	.07			
Sullivan, .....			.05	.06			
Susquehanna, .....	.21	.26	.05	.06			
Tioga, .....	.21	.26					.80
Union, .....	.20	.30	.05	.05	2.50	5.00	
Venango,							
Warren, .....	.17	.20	.05	.06			1.25
Washington, .....	.22	.30	.04	.05			1.80
Wayne, .....			.05	.07			.60
Westmoreland, .....			.05		4.20	5.00	
Wyoming, .....			.04	.05			1.00
York, .....			.07	.06	3.85	4.25	.80
Average,	\$0.20	\$0.27	\$0.06	\$0.05.6	\$3.67	\$4.64	\$1.18

CROP REPORT FOR 1900—Continued.

Counties.	Prices of Farm Products and Live Stock.									
	Milk at retail (per quart).	Buckwheat, per bushel.	Apples, per bushel.	Peaches, per basket.	Pears, per bushel.	Cherries, per quart.	Plums, per quart.	Strawberries, per quart.	Blackberries, per quart.	Raspberries, per quart.
Adams,	\$0.06	\$0.41	\$0.47	\$0.49	\$0.60	\$0.06	\$0.08	\$0.08	\$0.05	\$0.08
Allegheny, .....	.06	.45	.55	.83	1.06	.08	.10	.08	.09	.08
Armstrong, .....	.06	.40	.80	.99	.90	.06	.10	.09	.06	.08
Beaver, .....	.06	.57	.90	.87	1.25	.06	.08	.06	.07	.06
Bedford, .....		.57	.40							.06
Berks, .....	.07		.50	.70	.80	.06	.08	.07	.08	.10
Blair, .....	.07	.45	.63	1.00	1.12	.07	.08	.11	.07	.07
Bradford, .....	.04	.65	.30	.80	.35	.08	.10	.10	.08	.08
Bucks, .....	.04	.50	.40	.75	.60	.06	.08	.10	.08	.12
Butler, .....	.05	.55	.50	1.00	2.50	.05	.05	.08	.05	.05
Cambria, .....	.06	.46	.65	1.00	.96	.08	.08	.10	.08	.08
Cameron, .....	.06	.65	.60	.87	.90	.09	.05	.10	.06	.07
Carbon, .....	.06	.48	.50					.08	.08	.06
Centre, .....	.06	.40	.25	.75	.50	.08	.05	.06	.06	.06
Chester, .....	.05	.45	.50	.60	.62	.08	.04	.06	.06	.07
Clarion, .....	.06	.49	.25		1.00					
Clearfield, .....	.06	.66	.48	.83	.95	.08	.05	.11	.07	.08
Clinton, .....	.06	.60	.45	.60	1.00	.05	.06	.10	.08	.10
Columbia, .....	.06	.55	.50	.75	.67	.05		.09	.06	.07
Crawford, .....	.06	.46	.40	.60	.82	.09	.10	.07	.06	.08
Cumberland, .....	.05	.60	.87	.60	.65	.06	.05	.07	.06	.08
Dauphin, .....	.05	.45	.60	.52	.74	.04	.03	.07	.05	.08
Delaware, .....	.06	.45	.50	.70	.68	.10	.07	.06	.05	.07
Elk, .....	.06	.65	.60	1.00	1.10			.11	.04	.06
Erie, .....	.05	.52	.35	.87	.75	.10	.08		.06	.10
Fayette, .....	.08	.50	.70	.87	1.00	.12	.08	.10	.09	.10
Forest, .....	.06	.53	.58	1.00	1.00	.10	.10	.11	.06	.10
Franklin, .....	.05		.60	.75		.05		.10	.08	.10
Fulton, .....		.52	.53		1.00					
Greene, .....	.06	.60	.65	.60	.88	.06		.09	.06	.08
Huntingdon, .....	.06	.45	.62	.70	1.10	.07	.08		.07	.08
Indiana, .....	.05	.48	.50	.04	1.00			.08	.06	.08
Jefferson, .....	.05	.50	.50	1.00	1.00	.08	.05	.08	.06	.08
Junata, .....	.05		.80	.75	1.00	.05	.05	.08	.05	.06
Lackawanna, .....	.07	.55	.50		.70	.07	.04	.07	.06	.07
Lancaster, .....	.04		.75	.80	.75	.06	.08	.08	.07	.08
Lawrence, .....	.06	.59	.60		.83	.07	.05	.07	.06	.06
Lebanon, .....	.06		.60	.60	.80	.05	.05	.08	.06	.10
Lehigh, .....	.05	.50	.30	.60	.62	.05	.06	.06	.05	.07
Luzerne, .....	.08	.50	.50	.80	.90	.08	.05	.06	.06	.07
Lycoming, .....	.06	.67	.65	1.00	.93	.07	.06	.09	.08	.08
McKean, .....	.05	.55	.60	.90	1.00	.12	.10	.12	.05	.06
Mercer, .....	.05	.51	.33					.05	.05	.07
Mifflin, .....	.04	.60	.60	.60	1.00	.05	.05	.09	.06	.05
Monroe, .....	.05	.50	.25							
Montgomery, .....	.06		.65	.87	.63	.10	.10	.12	.12	.14
Montour, .....	.06	.52	1.00	.75	1.00	.08	.10	.10	.10	.08
Northampton, .....	.06	.59	.50	.50	.75	.07	.07	.10	.08	.08
Northumberland, .....	.06	.55	.65	.63	.87	.06	.08	.09	.08	.09
Perry, .....	.05	.46	.70	.75	.80	.05	.05	.06	.05	.06
Philadelphia, .....	.08		.50		.50		.12			
Pike, .....	.04	.55	.50	.45	.75	.05		.10	.05	.07
Potter, .....	.05	.60	.30	.80	1.00	.09	.05	.10	.06	.08
Schuylkill, .....	.06	.45	.50	.90	.70	.05	.08	.08	.06	.10
Snyder, .....	.05	.70	.60	.75	.75	.03	.05	.06	.05	.09
Somerset, .....	.10	.50	.40	1.00	1.00	.08	.08	.10	.05	.10
Sullivan, .....	.05	.50	.25	.75	.50	.10	.10	.08	.10	.10
Susquehanna, .....	.05	.55	.23	.70	.65	.08	.09	.07	.06	.07
Tioga, .....		.50	.40	1.00	.40	.10	.10	.08		.06
Union, .....	.06	.55	.55	.63	.57	.05	.10	.10	.07	.08
Venango, .....	.06	.55	.35	1.75	1.00	.08	.05	.06	.06	.07
Warren, .....	.05	.60	.45		.65	.09	.04	.09	.06	.07
Washington, .....	.06		.75			.10	.06	.08	.07	.08
Wayne, .....	.06	.50	.33	.90	.88	.10	.08	.08	.08	.08
Westmoreland, .....	.06	.45	.90	.90	1.20	.16	.06	.08	.06	.08
Wyoming, .....	.05	.55	.24	.90	.50	.05	.04	.08	.08	.06
York, .....	.05	.50	.75	.50	.75	.06	.06	.08	.08	.07
Average,	\$0.05	\$0.52	\$0.52	\$0.79	\$0.84	\$0.07	\$0.07	\$0.08	\$0.06	\$0.08

CROP REPORT FOR 1900--Continued.

Counties.	Farm Wages and Board.									
	By the month (whole year) with board.	By the month, for summer months only.	By the day with regular work (with board).	By the day with regular work (without board.)	By the month (whole year), without board.	By the summer months (without board).	By the day for transient work, when wanted only.	Harvest wages by the day.	Household help, female, (with board) by the week.	Estimated cost of boarding farm hands per day.
Adams,	\$11.00	\$12.75	\$0.76	\$0.90	\$17.25	\$17.75	\$0.82	\$1.00	\$1.44	\$0.26
Allegheny,	12.66	17.00	1.00	1.25	20.00	25.00	1.00	1.50	2.50	0.32
Armstrong,	13.00	17.00	.84	1.25	22.00	35.00	1.15	1.25	2.12	0.25
Beaver,	14.00	17.66	.86	1.08	20.00	26.00	1.00	1.17	3.75	0.25
Bedford,	11.50	12.66	.61	.82	16.00	18.00	.67	1.00	1.25	0.25
Berks,	13.00	16.00	.75	1.00	17.00	20.00	.80	1.00	1.82	0.26
Blair,	12.00	17.50	1.00	1.25	20.00	25.00	1.00	1.25	1.50	0.40
Bradford,	15.00	18.00	.75	1.00	18.00	20.00	1.00	1.25	1.25	0.25
Bucks,	18.00	20.00	1.00	1.25	16.00	25.00	1.25	2.00	2.00	0.30
Butler,	11.50	19.30	.91	1.25	18.50	26.00	1.00	1.00	2.16	0.26
Cambria,	16.00	21.00	.95	1.37	25.00	32.00	1.00	1.30	2.10	0.30
Cameron,	16.50	20.50	1.16	1.40	.....	.....	1.50	1.83	2.50	0.35
Carbon,	14.50	23.00	1.00	1.30	27.00	33.00	1.10	1.22	1.95	0.41
Centre,	12.00	16.00	.75	.92	22.00	27.00	1.00	1.25	1.50	0.32
Chester,	14.00	17.00	.83	1.16	24.00	28.00	1.30	1.60	1.12	0.45
Clarion,	13.30	16.00	1.00	1.28	19.00	22.50	1.00	1.00	2.30	0.27
Clearfield,	16.66	21.00	1.05	1.25	.....	.....	1.25	1.30	2.15	0.30
Clinton,	13.60	17.16	.82	1.10	16.00	.....	1.25	1.25	2.50	0.30
Columbia,	12.50	15.00	.75	1.00	21.00	24.50	1.12	1.25	1.75	0.35
Crawford,	13.40	17.40	.75	1.06	23.00	27.83	1.10	1.40	2.25	0.33
Cumberland,	12.50	14.00	.61	.98	17.00	17.00	.83	1.00	1.66	0.33
Dauphin,	10.66	13.00	.83	1.12	17.50	20.66	.92	1.25	1.94	0.23
Delaware,	19.00	20.00	1.00	1.50	25.00	.....	1.50	2.00	3.00	0.50
Elk,	13.00	24.00	1.00	1.42	35.00	40.00	1.62	1.75	2.50	0.38
Erie,	15.00	19.00	.94	1.18	22.50	27.00	1.20	1.62	2.16	0.43
Fayette,	16.00	18.50	1.00	1.25	20.00	26.00	1.00	1.25	1.75	0.39
Forest,	19.00	25.00	1.00	1.38	25.00	35.00	1.53	2.00	2.75	0.45
Franklin,	11.00	13.50	.73	.90	16.00	20.00	.83	1.23	1.65	0.28
Fulton,	10.00	11.90	.53	.75	17.00	18.50	.50	1.10	1.10	0.22
Greene,	13.60	17.66	.92	1.33	20.30	27.00	1.08	1.50	3.00	0.32
Huntingdon,	12.00	14.50	.70	1.03	18.00	18.00	.97	1.10	1.19	0.30
Indiana,	11.00	14.00	.70	.92	16.00	16.50	.92	1.08	1.66	0.40
Jefferson,	15.00	19.00	.87	1.25	24.50	30.00	1.13	1.37	2.00	0.40
Juniata,	9.50	12.00	.53	.75	15.00	19.00	.70	1.00	1.50	0.33
Lackawanna,	13.00	17.00	.92	1.16	21.00	25.00	1.25	1.30	2.00	0.33
Lancaster,	14.30	14.30	.73	1.08	18.30	19.00	.93	1.25	1.83	0.41
Lawrence,	14.00	18.00	.88	1.16	20.00	25.50	1.00	1.30	2.40	0.37
Lebanon,	12.00	14.50	.70	1.00	.....	20.00	.96	1.25	1.80	0.33
Lehigh,	14.00	15.00	.81	1.06	21.00	17.75	.96	1.18	1.87	0.37
Luzerne,	15.00	16.30	.92	1.25	24.30	30.30	1.25	1.58	2.00	0.36
Lycoming,	13.10	15.50	.83	1.20	31.00	25.00	1.10	1.30	2.00	0.33
McKean,	19.00	22.00	1.00	1.50	30.00	35.00	1.30	1.75	2.00	0.43
Mercer,	14.00	17.00	.83	1.37	20.00	23.00	1.08	1.25	2.10	0.36
Mifflin,	11.00	14.00	.61	.96	19.20	20.00	.83	1.04	1.50	0.35
Monroe,	16.00	19.00	.86	1.20	25.00	30.00	1.12	1.25	2.23	0.33
Montgomery,	14.50	19.00	1.00	1.33	27.50	31.00	1.32	2.00	3.00	0.38
Montour,	10.00	13.00	.68	.92	14.50	17.00	.85	1.08	1.75	0.26
Northampton,	11.50	14.50	.90	1.10	22.50	24.00	1.25	1.75	2.25	0.35
Northumberland,	12.10	14.00	.75	1.00	19.75	26.00	.75	1.10	3.00	0.40
Perry,	10.00	12.00	.75	1.00	14.00	16.25	.78	1.04	1.50	0.22
Philadelphia,	18.50	20.00	1.00	1.25	25.00	28.00	1.50	2.00	3.00	0.50
Pike,	11.60	16.30	.75	1.00	17.50	27.50	1.00	1.40	2.50	0.25
Potter,	15.00	18.00	1.00	1.25	20.00	26.00	1.10	1.50	3.08	0.36
Schuylkill,	18.00	25.00	.75	1.00	20.00	30.00	.87	1.00	2.00	0.20
Snyder,	10.00	13.00	.82	1.13	14.00	18.00	.97	1.00	1.65	0.35
Somerset,	14.00	18.00	.87	1.12	16.00	20.00	1.00	1.18	1.75	0.40
Sullivan,	12.50	17.50	.80	1.25	20.00	26.00	1.25	1.50	1.75	0.34
Susquehanna,	14.00	16.00	1.00	1.25	20.00	26.00	1.25	1.50	2.00	0.35
Tioga,	13.60	16.60	.83	1.20	24.00	26.50	1.00	1.25	2.30	0.37
Union,	10.00	13.00	.70	1.13	17.00	25.00	1.00	1.25	1.75	0.28
Venango,	10.00	16.00	.95	1.25	22.50	26.50	1.00	1.23	2.00	0.30
Warren,	15.00	19.00	1.00	1.25	22.00	.....	1.25	1.95	3.50	0.30
Washington,	16.00	18.00	1.00	1.30	21.00	25.00	1.25	1.50	2.00	0.45
Wayne,	16.00	19.00	.88	1.25	30.00	30.00	1.00	1.37	2.00	0.33
Westmoreland,	14.00	16.00	1.00	1.30	20.00	26.00	1.50	1.40	2.50	0.45
Wyoming,	15.00	17.00	1.00	1.25	20.00	25.00	1.16	1.50	2.16	0.33
York,	10.80	14.00	.75	1.00	18.00	20.00	1.00	1.08	2.00	0.26
Average,	\$13.58	\$16.94	\$0.85.4	\$1.15	\$20.55	\$24.76	\$1.07	\$1.35	\$2.04	\$0.35

List of County and Local Agricultural Societies, with Names and Addresses of Secretaries and Date for Holding Fall Exhibitions of 1900.

[Those marked with an * are represented in the Board of Agriculture by elected members.]

COUNTY.	Corporate Name of Society.	Name and Address of Secretary.	Where Held.	When Held.
	PENNSYLVANIA STATE AGRICULTURAL SOCIETY,	J. P. Nisley, Hummelstown, ..		
	STATE HORTICULTURAL ASSOCIATION	E. E. Engle, Waynesboro, ..		
	GRANGERS' INTERSTATE PICNIC EXHIBITION,	R. H. Thomas, Mechanicsburg, ..		
	MT. GRETA AGRICULTURAL, MECHAN. & INDUS. EX., ..	Dr. S. P. Hellman, Hellmandale, ..	Williams' Grove,	No fair.
	STRONGS OF HUSBANDRY EXHIBITION,	L. Rhone, Centre Hall,	Mc. Gretna,	Aug. 27, Sept. 1
	PENNSYLVANIA STATE DAIRYMEN'S ASSOCIATION,	G. H. St. John, Meadville, ..	Centre Hall,	Aug. 20-24,
	Adams County Agricultural Association,	A. I. Weldner, Ardenstville, ..		Sept. 18-22,
Adams,*	Tarentum Fair Association,	J. C. Dunn, Tarentum,		
Allegheny,*	Clinton Agricultural Association,	J. S. Burns, Clinton,		No fair.
Do.	Dayton Agricultural and Mechanical Association, ..	E. Morrow, Dayton,	Dayton,	No fair.
Armstrong,*	Parker Tri-County Fair Association,	S. W. Coe, Parkers' Landing, ..		Sept. 25-28,
Do.	Kittanning Fair Association,	T. McConnell, Kittanning, ..	Kittanning,	Aug. 22-25,
Do.				
Beaver,*	Beaver County Agricultural Society,	J. C. Martin, Beaver,		No fair.
Do.	Mill Creek Valley Agricultural Society, Limited,	R. M. Swaney, Hookstown, ..	Hookstown,	Aug. 21-22,
Bedford,*	Bedford County Agricultural Society,	Wm. I. Elcholtz,	Bedford,	Oct. 2-5,
Berks,*	Agricultural and Horticultural Association of Berks County,	Cyrus T. Fox, Reading,	Reading,	Oct. 2-5,
Do.	Keystone Agricultural Society,	J. B. Esser, Kutztown,	Kutztown,	Sept. 25-28,
Blair,*	Blair County Agricultural Society,	Frank H. Fay, Hollidaysburg, ..	Hollidaysburg,	Sept. 11-14,
Bradford,*	Bradford County Agricultural Society,	Benj. Kuykendall, Jr., Towanda,	Towanda,	Sept. 25-28,
Do.	Union Agricultural Association,	C. D. Derrah, Canton,	Canton,	Sept. 1-7,
Do.	Troy Agricultural Society,	Charles L. Fellows, Troy,	Troy,	Sept. 11-14,
Butler,*	Butler County Agricultural Society,	W. P. Roessing, Butler,	Butler,	Sept. 4-7,
Cambria,*	Ebensburg Agricultural Society,	F. C. Sharbaugh, Ebensburg, ..	Ebensburg,	Aug. 22-25,
Do.	Cambria County Agricultural Association,	J. V. Maucher, Carrolltown, ..	Carrolltown,	Sept. 4-7,
Do.	Tri-County Agricultural and Driving Park Association,	J. H. Laine, Johnstown,		
Cameron,*	Cameron County Agricultural Association,	N. A. Ostrum, Emporium,		No fair.
Carbon,	Carbon County Industrial Society,	C. W. Bower, Lehighton,	Lehighton,	Sept. 25-28,

List of County and Local Agricultural Societies—Continued.

[Those marked with an * are represented in the Board of Agriculture by elected members.]

COUNTY.	Corporate Name of Society.	Name and Address of Secretary.	Where Held.	When Held.
Chester.*	Chester County Agricultural Society.	B. Lear, West Chester.	.....	No fair.
Do.	Oxford Agricultural Society.	T. S. F. Grier, Oxford.	.....	Sept. 24-28.
Clarion.*	Clarion County Fair Association.	T. S. F. Grier, Clarion.	.....	Sept. 24-28.
Clerfield.*	Clerfield County Agricultural Society.	R. E. Shaw, Clearfield.	.....	Sept. 11-14.
Clinton.*	Clinton County Agricultural Society.	J. R. Porter, Macksville.	.....	No fair.
Columbia.*	Columbia County Agricultural Society.	A. N. Yost, Bloomsburg.	.....	Oct. 9-12.
Crawford.*	Crawford County Agricultural Association.	Frank Clancy, Conneautville.	.....	Sept. 4-6.
Do.	Central Crawford Agricultural Society.	A. S. Faber, Cambridge Springs.	.....	Aug. 28-31.
Cumberland.*	Cumberland County Agricultural Society.	W. H. McCrea, Carlisle.	.....	Sept. 25-28.
Dauphin.*	Gratz Driving Park and Agricultural Society.	J. W. Hoffman, Gratz.	.....	No fair.
Do.	Agricultural Society of Dauphin County.	G. Hiestor, Harrisburg.	.....	No fair.
Delaware.*	Delaware County Agricultural Society.	Joseph H. Paschall, Ward.	.....	No fair.
Eric.*	Wattsburg Agricultural Society.	A. L. Phelps, Wattsburg.	.....	Sept. 4-6.
Do.	Edinboro' Agricultural Society.	John Prouditt, Edinboro'.	.....	Sept. 25-28.
Fayette.*	Fayette Fair Association.	W. W. Parrshall, Uniontown.	.....	Sept. 4-7.
Fulton.*	Rig Cove Agricultural Society.	W. C. Patterson, McConnellsburg.	.....	No fair.
Greene.*	Greene County Agricultural and Mechanical Society.	C. R. Berkman, Carmichaels.	.....	Oct. 3-4.
Do.	Greene County Agricultural and Horticultural Society.	J. R. Phelps, Wymersburg.	.....	Sept. 18-21.
Do.	Wattsburg Fair Association.	J. S. Carter, Wymersburg.	.....	Sept. 11-14.
Huntingdon.*	Huntingdon County Agricultural Society.	W. A. Neff, Warriors Mark.	.....	Aug. 21-24.
Indiana.*	Indiana County Agricultural Society.	David Blair, Indiana.	.....	Sept. 12-14.
Jefferson.*	Jefferson County Agricultural Society.	S. H. Whitehill, Brookville.	.....	Sept. 27-29.
Do.	Punxsutawney Fair Association.	P. O. Frens, Punxsutawney.	.....	No fair.
Do.	Punxsutawney Agricultural Society.	D. M. McQuown, Punxsutawney.	.....	Sept. 4-7.
Junata.*	Junata County Agricultural Society.	J. N. Groninger, Port Royal.	.....	Sept. 12-14.
Lackawanna.*	North Abington and Glenburn Farmers' Club.	Isaac Ellis, Glenburn.	.....	Sept. 27-29.
Lancaster.*	Lancaster County Agricultural Society.	Simon L. Brandt, Marietta.	.....	No fair.
Do.	Lancaster County Agricultural and Horticultural Society.	F. R. Dittenderfer, Lancaster.	.....	Sept. 4-7.
Lawrence.*	Lawrence County Agricultural Society.	H. W. Grigsby, New Castle.	.....	Sept. 27-29.
Lebanon.*	Lebanon County Agricultural and Horticultural Association.	Dr. R. P. Hellman, Hellmanville.	.....	No fair.
Do.	Lebanon Valley Fair Association.	Dr. W. B. Matus, Lebanon.	.....	Sept. 4-7.

Lehigh.*	Lehigh County Agricultural Society.	W. K. Mohr, Allentown.	Allentown.	Sept. 13-21.
Luzerne.*	Dallas Union Agricultural Association.	Wm. Norton, Dallas.	Dallas.	Oct. 2-5.
Lycoming.*	Muncy Valley Farmers' Club.	A. C. Henry, Hughesville.	Hughesville.	Sept. 13-22.
McKean.	McKean County Agricultural Society.	J. B. Colcord, Port Allegany.	Port Allegany.	Sept. 13-21.
Do.	Agricultural and Breeders' Society.	James Quirk, Smethport.	Smethport.	No fair.
Mercer.	Mercer County Agricultural Society.	Geo. H. Fowler, Stoneboro'.	Stoneboro'.	Oct. 2-4.
Do.	Mercer Central Agricultural Association.	Jno. E. Mowry, Mercer.	Mercer.	Sept. 25-27.
Mifflin.*	Mifflin County Agricultural Society.	A. T. Hamblin, Lewistown.	Lewistown.	No fair.
Monroe.*	Monroe County Agricultural Society.	H. L. Lambert, Stroudsburg.	Stroudsburg.	Sept. 4-7.
Montour.*	Montour County Agricultural Society.	W. K. West, Danville.	Danville.	Oct. 2-5.
Northampton.*	Northampton County Agricultural Society.	J. J. Maus, Nazareth.	Nazareth.	Sept. 11-14.
Do.	Pennsylvania State Fair Association.	H. A. Groman, Bethlehem.	Bethlehem.	Oct. 2-5.
Northumberland.*	Milton Driving Park and Fair Association.	Edwin Paul, Milton.	Milton.	Oct. 2-5.
Perry.*	Perry County Agricultural Society.	C. A. Diven, Newport.	Newport.	Sept. 13-21.
Philadelphia.*	Pennsylvania Horticultural Society.	David Rust, Philadelphia.	Philadelphia.	Nov. 13-17.
Potter.*	Potter County Agricultural and Horticultural Society.	C. L. Peck, Coudersport.	Coudersport.	No fair.
Do.	Farmers' and Breeders' Association.	D. S. Liebert, Coudersport.	Coudersport.	No fair.
Schuylkill.*	Orwigsburg Agricultural and Horticultural Society.	A. E. Brown, Orwigsburg.	Orwigsburg.	Aug. 23-31.
Do.	Ringtown Agricultural Society.	L. Applegate, Shenandoah.	Shenandoah.	Sept. 11-15.
Somerset.*	Somerset County Agricultural Society.	H. J. Hoffman, Somerset.	Somerset.	Oct. 3-5.
Sullivan.*	Sullivan County Agricultural Society.	O. N. Molyneux, Millview.	Millview.	Sept. 13-19.
Susquehanna.*	Susquehanna County Agricultural Society.	W. A. Titaworth, Montrose.	Montrose.	Sept. 13-17.
Do.	Harford Agricultural Society.	E. E. Jones, Harford.	Harford.	Sept. 26-27.
Tioga.*	Cowanesque Valley Agricultural Society.	Frank Strong, Westfield.	Westfield.	Sept. 11-15.
Do.	Smythe Park Association.	W. P. Austin, Mansfield.	Mansfield.	Sept. 11-15.
Do.	Tioga County Pomona Grange.	H. Robbier, Balaam.	Balaam.	Sept. 25-28.
Union.*	Union County Agricultural Society.	C. Dale Wolfe, Bucknell.	Bucknell.	Sept. 13-23.
Vanango.*	Vanango County Agricultural Society.	James Miller, Franklin.	Franklin.	No fair.
Do.	Oil City Fair and Trotting Association.	I. K. Hinderliter, Oil City.	Oil City.	Sept. 11-14.
Washington.*	Western Pennsylvania Agricultural Association.	Jas. S. Forythe, Washington.	Washington.	Sept. 25-28.
Do.	Union Agricultural Association.	R. P. Stevenson, S. Burgettstown.	Burgettstown.	Oct. 2-4.
Wayne.*	Wayne County Agricultural Society.	E. W. Gammell, Bethany.	Bethany.	Sept. 13-21.
Westmoreland.	Westmoreland Agricultural Society.	W. F. Holtzer, Greensburg.	Greensburg.	Sept. 13-21.
Wyoming.*	Wyoming County Agricultural Society.	W. N. Reynolds, Tunkhannock.	Tunkhannock.	Sept. 13-21.
York.*	York County Agricultural Society.	E. Chapin, York.	York.	Oct. 1-5.
Do.	Hanover Agricultural Society.	M. O. Smith, Hanover.	Hanover.	Sept. 7-22.

Note.—Where dates are omitted, no replies to requests for same were received by this Department.

LIST OF BOOKS FOR FARMERS' LIBRARY.

COMPILED BY MISS MIRA LLOYD DOCK, *Harrisburg, Pa.*

AGRICULTURE.

GENERAL AGRICULTURE.

	Price.
AGRICULTURE. By C. C. James. Published by Morong & Co., Toronto, Can.,	\$0 25
AGRICULTURE. By F. H. Storer. Published by Orange Judd Co., N. Y. (3 vols.),	5 00
AGRICULTURE (NEW). By Wallace. Published by J. B. Lippincott & Co., Philadelphia,	1 25
AMERICAN FARM BOOK. By R. L. Allen. Published by Orange Judd Co., N. Y.,	2 00
ELEMENTS OF AGRICULTURE. By Gulley. Published by Rural Pub. Co., N. Y.,	75
ELEMENTS OF AGRICULTURE. By Col. Waring. Published by Orange Judd Co., N. Y.,	1 00
FIELD NOTES ON AGRICULTURE (1886). By L. H. Bailey. Published by Macmillan & Co., N. Y.,	
FIRST PRINCIPLES OF AGRICULTURE. By Mills & Shaw. Published by Bryant Pub. Co., Toronto, Can.,	40
FIRST PRINCIPLES OF AGRICULTURE. By E. B. Voorhees. Published by Silver, Burdette & Co., Boston,	1 00
GRASSES OF NORTH AMERICA. By W. J. Beal. Published by Orange Judd Co., N. Y.,	2 50
HOW THE FARM PAYS. By Henderson & Crozier. Published by Orange Judd Co., N. Y.,	2 00
MANUAL OF AGRICULTURE. By Flint & Goessman. Published by Orange Judd Co., N. Y.,	1 00
PLANT LIFE ON THE FARM. By M. T. Masters. Published by Orange Judd Co., N. Y.,	1 00
PRAIRIE AGRICULTURE. By George Bryce. Published by W. J. Gage & Co., Toronto, Can.,	50
PRINCIPLES OF AGRICULTURE. By L. H. Bailey. Published by Macmillan & Co., N. Y.,	1 25

AGRICULTURE—Continued.

Price.

PUBLIC SCHOOL AGRICULTURE. By Mills & Shaw.	
Published by Bryant & Co., Toronto, Can.,	40
WEEDS: HOW TO ERADICATE THEM. By Prof. Shaw.	
Published by Orange Judd Co., N. Y.,	1 00

AGRICULTURAL CHEMISTRY.

CHEMISTRY OF SOILS AND FERTILIZERS. By H. Snyder.	
Published by Chemical Pub. Co., Easton, Pa.,	1 50
CHEMISTRY OF THE FARM. By R. Warrington.	
Published by Orange Judd Co., N. Y.,	1 75
ELEMENTARY CHEMISTRY . (Briefer Course). By Ira Remsen.	
Published by H. Holt & Co., N. Y.,	80
PRACTICAL FARM CHEMISTRY. By T. Greiner.	
Published by Orange Judd Co., N. Y.,	1 00
THE CHEMISTRY OF THE GARDEN. By H. H. Cousins.	
Published by Macmillan & Co., N. Y.,	35

CROPS.

AMERICAN SUGAR INDUSTRY. By Herbert Myrick.	
Published by Orange Judd Co., N. Y.,	1 50
BROOM CORN AND BROOM.	
Published by Orange Judd Co., N. Y.,	50
COTTON AND ITS PRODUCTS. By Brooks.	
Published by N. W. Henley & Co., N. Y.,	3 00
DISEASES OF FIELD AND GARDEN CROPS. By Smith.	
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TABULATED STATEMENT BY COUNTIES, OF LOSSES FROM FOREST FIRES, FOR THE YEAR 1899.

County.	Number of acres burned over.	Number of feet (board measure) of logs burned.	Number of feet (board measure) of sawed lumber burned.	Number of railroad ties burned.	Number of mine props burned.	Number of cords of pulp wood burned.	Number of cords of cord wood burned.	Number of cords of bark burned.	Number of panels of fence burned.	Number of buildings burned.	Value of buildings burned.	Cost to individuals to extinguish fires.	Number of men employed by individuals.	Number of days employed.	Total loss by reason of forest fires.
Adams,	140	.....	.....	.....	.....	.....	.....	.....	200	.....	.....	.....	.....	10	\$600
Allegheny,	35	.....	5,000	.....	.....	.....	.....	.....	50	.....	.....	.....	.....	10	120
Armstrong,	12	.....	.....	.....	.....	.....	.....	.....	160	.....	.....	.....	.....	1	100
Beaver,	156	.....	.....	.....	.....	.....	.....	.....	523	.....	.....	.....	.....	15	125
Bedford,	5,463	.....	10,000	560	500	20	.....	82	2,016	.....	.....	\$128 00	114	123	9,041
Berks,	131	.....	.....	.....	200	.....	15	.....	.....	.....	.....	.....	.....	.....	2,012
Blair,	4,241	.....	4,000	.....	.....	.....	.....	.....	1,605	.....	.....	32 00	88	198	7,785
Bradford,	463	.....	.....	.....	.....	.....	.....	15	508	.....	.....	57 00	55	62	1,445
Bucks, .....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Butler,	110	.....	.....	.....	.....	.....	.....	.....	323	.....	.....	35 00	19	20	585
Cambridge,	2,239	.....	.....	.....	300	.....	.....	.....	1,167	1	\$5 00	67 00	108	253	8,765
Cameron,	9,560	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	621 00	18	14	10,128
Carbon,	7,955	.....	.....	.....	.....	.....	.....	50	934	2	3,500 00	112 00	30	64	14,515
Centre,	26,688	.....	.....	17	.....	14	1	1	1,605	.....	.....	148 00	77	94	25,987
Chenier,	7	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	100
Clarion,	223	.....	.....	.....	.....	.....	.....	.....	25	.....	.....	120 00	3	3	1,906
Clearfield,	15,395	.....	.....	.....	.....	.....	.....	.....	4,011	.....	.....	532 00	144	537	27,295
Clinton,	7,856	.....	.....	.....	.....	10	.....	.....	230	.....	.....	1,520 00	80	86	15,665
Columbia,	1,047	.....	.....	.....	.....	50	.....	.....	300	.....	.....	44 00	62	94	1,800
Crawford,	472	.....	.....	.....	.....	.....	.....	.....	265	.....	.....	7 00	3	6	1,218
Cumberland,	4,678	.....	.....	.....	.....	.....	.....	.....	125	.....	.....	115 00	4	8	7,960
Dauphin,	3,265	.....	.....	.....	.....	.....	10	.....	.....	.....	.....	75 00	5	50	4,975
Delaware,	825	.....	.....	.....	.....	.....	.....	.....	386	.....	.....	30 00	.....	.....	400

Elk.	13,350	500	925	1	500 00	144 00	11	13	14,400
Erie,	331		925			75 00	13	76	3,140
Fayette,	4,793		1,173			57 00	46	83	5,546
Forest,	1,188		100			545 00	112	294	5,870
Franklin,	4,731	142				132 00	33	74	14,540
Fulton,	3,617	20				95 00	12	48	4,215
Greene,									
Huntingdon,	13,332	225	340	35		193 00	116	206	24,880
Indiana,	666	7				81 00	55	100	3,790
Jefferson,	662					150 00	25	64	8,710
Juniata,	667		10			13 00	57	60	2,865
Lackawanna,	2,288					84 00	53	116	5,990
Lancaster,	127	2					10	5	690
Lawrence,			200						
Lebanon,	1,707					62 00	101	78	2,160
Lehigh,	99					10 00			850
Luzerne,	12,895		1,640	3	1,450 00	1,464 00	179	612	24,895
Lycoming,	6,921	200	1,646			886 00	106	183	10,646
McKean,									
Mercer,	33		90			28 00	12	23	235
Mifflin,	49		107						170
Monroe,	3,481		50			12 00	8	13	5,900
Montgomery,									
Montour,	150		10			20 00	35	22	1,620
Northampton,	443	5	15			35 00	26	22	1,685
Northumberland,	10,204		120	6		35 00	74	120	15,211
Perry,	1,913	47	23	10		81 00	115	120	2,309
Philadelphia,									
Pike,	11,079	50,000							
Potter,	2,134		630	1	700 00		31	46	14,945
Schuylkill,	9,984	4,300				1,500 00	54	133	8,335
Snyder,	123		310	1	50 00	43 00	77	63	21,330
Somerset,	3,297		120			12 00	16	8	386
Sullivan,	1,330		3,153			442 00	189	579	13,848
Susquehanna,	1,795	12,000	15			191 00	51	241	4,010
Tioga, †	1,205		1,568			47 00	66	223	8,183
Union,	1,400	50	410	1	100 00	225 00	70	265	4,120
Venango,	1,425	2		1	50 00	50 00	10	50	1,600
Warren,	3,210	50	885			25 00	44	71	3,250
Washington,	3		530	9	1,300 00	411 00	89	402	8,370
			15				6	2	15

TABULATED STATEMENT—Continued.

County.	Number of acres burned over.	Number of feet (board measure) of logs burned.	Number of feet (board measure) of sawed lumber burned.	Number of railroad ties burned.	Number of mine props burned.	Number of cords of pulp wood burned.	Number of cords of cord wood burned.	Number of cords of bark burned.	Number of panels of fence burned.	Number of buildings burned.	Value of buildings burned.	Cost to individuals to extinguish fires.	Number of men employed by individuals.	Number of days employed.	Total loss by reason of forest fires.
Wayne,	213	.....	.....	.....	.....	.....	.....	.....	280	.....	.....	2 00	15	23	635
Westmoreland,	967	.....	.....	.....	.....	.....	.....	.....	335	.....	.....	43 00	26	50	2,025
Wyoming,	1,714	.....	.....	.....	.....	.....	.....	.....	614	.....	.....	233 00	49	94	3,945
York,	37	.....	.....	.....	.....	13	.....	.....	100	.....	.....	.....	63	16	660
Total,	214,051	50,000	31,000	767	5,300	1,170	908	638	35,444	25	\$9,055 00	\$9,502 00	2,917	6,346	\$408,531

Clearfield, one cow, \$15.00. †Tioga, 50,000 shingles.

TABULATED STATEMENT OF TIMBER CUT IN PENNSYLVANIA IN 1899.

County.	Number of acres cut over.	Number of acres cut over to be used for farming purposes.	Number of feet (board measure) white pine cut.	Number of feet (board measure) hemlock cut.	Number of feet (board measure) other woods cut.	Number of cords of bark peeled.
Adams,	576	100	363,000	105,000	3,237,400	40
Allegheny,	353	105	.....	100,000	2,362,000	.....
Armstrong,	547	410	.....	120,000	3,599,200	.....
Beaver,	235	10	.....	.....	1,373,000	.....
Bedford,	1,367	369	889,000	151,000	4,905,100	1,431
Berks,	222	13	50,000	.....	2,850,000	77
Blair,	1,039	112	1,163,000	305,000	16,349,400	135
Bradford,	2,566	604	1,280,000	12,427,800	5,440,500	9,609
Bucks,	149	52	.....	.....	1,532,000	56
Butler,	270	30	.....	.....	2,225,000	.....
Cambria,	6,229	439	2,144,500	39,508,000	17,165,000	18,965
Cameron,	14,760	3,200	3,041,100	33,293,100	1,231,400	21,280
Carbon,	100	25	60,000	400,000	39,500	130
Centre,	5,947	491	6,265,000	4,126,900	22,577,600	1,861
Chester,	433	29	.....	.....	22,913,800	.....
Clarion,	2,090	120	3,640,000	3,518,000	10,456,000	.....
Clearfield,	16,565	1,413	23,984,400	94,913,200	21,078,300	40,000
Clinton,	11,510	190	6,440,600	12,534,800	18,186,400	3,780
Columbia,	762	450	675,000	725,000	366,000	.....
Crawford,	899	230	395,000	2,409,000	6,164,500	593
Cumberland,	170	45	253,500	2,000	1,519,000	50
Dauphin,	102	4	415,000	600,000	1,985,200	43
Delaware, .....	.....	.....	.....	.....	20,130	.....
Elk,	6,535	215	3,704,500	72,078,800	26,100,200	41,586
Erie,	304	118	120,000	325,000	2,340,000	125
Fayette,	557	159	.....	.....	8,252,000	80
Forest,	6,879	55	16,775,600	83,481,000	.....	40,103
Franklin,	1,630	230	441,000	31,000	5,280,000	681
Fulton,	1,745	.....	1,525,000	.....	1,143,000	160
Greene,	60	40	.....	.....	506,000	.....
Huntingdon,	6,551	116	2,506,900	136,000	16,120,600	2,675
Indiana,	3,459	864	2,256,300	16,420,800	12,708,800	17,504
Jefferson,	2,450	526	1,842,400	47,694,200	9,738,800	20,755
Junata,	1,324	190	740,000	50,000	4,249,000	200
Lackawanna,	1,050	.....	300,000	850,000	3,748,000	385
Lancaster,	408	113	.....	.....	6,327,600	123
Lawrence,	258	126	.....	.....	2,285,000	.....
Lebanon,	238	87	165,000	75,000	3,304,000	75
Lehigh,	61	33	.....	.....	2,001,000	91
Luzerne,	1,412	64	1,398,900	2,155,700	5,717,200	808
Lycoming,	6,707	652	9,402,800	30,753,500	9,472,800	23,563
McKean,	5,400	500	300,000	73,205,500	32,547,500	25,224
Mercer,	317	150	.....	.....	1,792,000	.....
Mifflin,	3,238	.....	843,000	100,000	6,254,200	187
Monroe,	220	.....	200,000	135,000	2,773,400	.....
Montgomery,	35	21	.....	.....	1,768,000	.....
Montour,	915	215	330,000	5,000	4,849,900	1,100
Northampton,	296	150	91,200	25,000	3,385,000	343
Northumberland,	91	73	25,000	10,000	9,817,000	331
Perry,	553	100	250,000	50,000	17,567,200	2,305
Philadelphia, .....	.....	.....	.....	.....	.....	.....
Pike,	1,005	110	439,000	4,774,000	2,568,700	2,343
Potter,	9,304	3,004	684,700	216,723,900	32,266,900	83,046
Schuylkill,	1,988	95	1,794,800	2,073,200	11,594,000	1,052
Snyder,	57	.....	139,000	20,000	113,400	22
Somerset,	4,227	165	497,500	19,777,600	17,836,600	12,993
Sullivan,	3,540	10	497,300	35,801,900	16,919,000	24,550
Susquehanna,	941	229	50,000	2,438,000	16,998,000	1,771

TABULATED STATEMENT—Continued.

	Number of acres cut over.	Number of acres cut over to be used for farming purposes.	Number of feet (board measure), white pine cut.	Number of feet (board measure) hemlock cut.	Number of feet (board measure) other woods cut.	Number of cords of bark peeled.
Tioga,	3,525	239	1,356,200	30,194,100	4,310,000	13,455
Union,	1,530	99	3,640,000	1,795,000	9,197,200	1,122
Venango,	1,348	141	575,000	568,000	8,894,300	100
Warren,	7,940	230	14,111,700	45,848,700	17,793,900	16,906
Washington,	445	332			3,237,500	
Wayne,	859	306	355,000	980,000	26,341,000	521
Westmoreland,	2,102	572		700,000	12,719,400	20
Wyoming,	1,445	148	2,735,000	3,776,000	5,425,800	3,065
York,	406	192		30,000	8,384,000	100
Total,	126,626	28,659	121,101,900	897,315,500	562,732,500	453,160

STATISTICS OF GREEN HOUSE INDUSTRY IN PENNSYLVANIA FOR 1900. COMPILED BY BENJAMIN F. MACCARTNEY,
ECONOMIC ZOOLOGIST.

Counties.	Give total square feet of glass in greenhouses.	Give total square feet of glass in cold frames.	Give area of land culti- vated.	Give value of establish- ments.	State amount of annual business.	State amount of annual expense.	Give number of persons employed—men, women and children.	Plants propagated.
Adams,	203,900	19,000	69%	\$94,400 00	\$45,650 00	\$37,000 00	50	170,500
Allegheny,	2,000	800	5	1,000 00	2,500 00	1,750 00	2	
Armstrong,	5,163	887	10%	2,400 00	1,065 00	464 00	1	1
Beaver,	540	144	3%	300 00	300 00	20 00	1	
Bedford,	3,700			3,800 00	2,000 00		1	1
Berks,	38,000	860	5%	20,600 00	8,000 00	6,000 00	7	32,500
Blair,	3,000		3%	1,500 00			1	
Bradford,	87,700	4,960	22%	182,645 00	54,699 50	33,325 00	80	
Bucks,	2,000			3,500 00				
Butler,	18,520	3,856	2%	30,000 00	8,742 04	5,116 75	5	3
Cambria,								
Cameron,	3,480	180	3%	1,400 00	600 00	300 00		
Carbon,								
Centre,								
Chester,	203,816	7,250	10%	97,400 00	42,200 00	17,043 00	46	5
Clarion,								
Clearfield,								
Clinton,	91,800	1,000	75	50,400 00	16,100 00	40 00	22	455,000
Columbia,	3,500	180	3%	5,000 00		1,175 00	2	
Crawford,	11,100	500	7%	6,300 00	3,200 00	1,450 00	3	1
Cumberland,	2,300	432		1,600 00	800 00	150 00	1	
Dauphin,	160,000	2,532	13%	79,000 00	44,446 90	19,608 15	33	3
Delaware,								20,000
Elk,								
Erie,	40,460	3,530	32%	20,000 00	8,700 00	2,500 00	13	13 000

	453,520	110,908	157%	560,900 00	142,562 72	71,183 45	121	22	39	440,500
Philadelphia,										
Pike,										
Potter,										
Schuykill,	12,500	2,500	2%	11,000 00	6,100 00	2,000 00	5	1	1	
Snyder,										
Somerset,										
Sullivan,										
Susquehanna,	4,000	900	21	4,000 00	1,700 00	650 00	7	1	3	
Tioga,	10,000		2	2,500 00	2,000 00	300 00	2			
Union,										
Venango,	21,775	1,298	1½	8,500 00	2,300 00	1,607 50	9			
Warren,	14,600	1,200	4	1,200 00	3,500 00	2,025 00	3			12,000
Washington,	14,800	7,500	21	10,500 00	3,000 00	800 00	7	3	1	
Wayne,										
Westmoreland,	3,500	500	½	2,000 00	550 00	100 00				2,000
Wyoming,										
York,	2,040			900 00			1			
Total,	2,433,324	226,575	1,185½	\$1,330,570 00	\$653,269 16	\$313,867 85	674	22	39	2,076,100

STATISTICS—Continued.

Counties.	Value of plants propa- gated.	State total cut flower sales.	State total sale of roses.	State total sales of carna- tions.	State total sales of chrys- anthemums.	State total sale of potted plants.	Value of greenhouse vege- tables.	State annual loss as nearly as possible by insects and fungous diseases.
Adams,	\$4,150 00	\$27,000 00	\$8 00	\$500 00		\$6,450 00	\$575 00	\$350 00
Allegheny,		500 00				100 00	100 00	
Armstrong,	500 00	350 00		230 00	\$80 00	1,370 00		3 00
Beaver,	200 00	100 00						
Bedford,								
Berks,								
Blair,							49 00	
Bradford,								
Bucks,	700 00	7,930 00	152 50	2,447 40	200 00	1,311 00		
Butler,								
Cambria,		432 00			716 00			
Cameron,								
Carbon,								
Centre,								
Chester,	10,720 00	19,213 81		14,684 70	612 00	410 00	6,123 76	760 00
Clarion,								
Clearfield,								
Clinton,								
Columbia,				80 00		20 00		
Crawford,								
Cumberland,	2,000 00	400 00					150 00	
Dauphin,	250 00	250 00	75 00	168 00	50 00	500 00		
Delaware,	3,000 00	23,523 55	6,800 00			1,600 00		250 00
Elk,								
Erie,								
Fayette,							3,075 00	
Forest,					12 00	380 00		

[illegible]

SPRAYING CALENDAR.

A BRIEF OUTLINE OF THE BEST METHODS FOR THE PROTECTION OF CROPS FROM INSECTS AND FUNGI.

The utility of some condensed outline showing how and when to spray or otherwise treat the fruit trees, shade trees, garden and field crops, and flowers, to prevent or check injuries by insects and plant diseases, is demonstrated by the number of such publications in other States. It is practically impossible, however, to include in such a paper, all of the foes of the agriculturist, and accordingly, only such are considered as have been found to be most likely to be present in Pennsylvania. At the same time, treatment for the injuries touched on here, will, in nearly every case, also control those not treated of, and accordingly, in this way the ground will be nearly as well covered as though all such foes were considered in detail.

In all cases, treatment according to the directions here given must be applied with judgment, as no fixed rules can be given which will hold for every case, and an ignorant adherence to the directions without a knowledge of the particular conditions of the case, may fail to give the desired results. To obtain success in the control of insect and fungous foes, a knowledge of what the foe is, the best way to attack it, and when this attack is most effective, are necessary.

Any information desired on these subjects may be obtained by writing to the Division of Zoology, Department of Agriculture, Harrisburg, Pa., and the sending of samples of injury done, or of the insects or other foes causing the trouble will greatly aid in giving satisfactory answers.

Apple.

CODLING MOTH:

1. Paris green or Arsenate of Lead as soon as blossoms have fallen.
2. Repeat about ten days later.
3. Repeat in severe cases two weeks later.
4. Repeat about August 1 for second brood. See Report of Department for 1898.

BUD-MOTH:

1. Paris green or Arsenate of Lead as soon as leaf buds become green.
2. Repeat 1 just before blossoms open.
3. Repeat 2 after blossoms fall.

CANKER-WORM:

1. Paris green or Arsenate of Lead when caterpillars appear.
2. Same ten days later.
3. Repeat every ten days if needed.

TENT CATERPILLAR:

1. Destroy tents at night by torch.
2. If any escape, treatment for Codling moth will destroy them. See report of Department for 1898.

PLUM CURCULIO:

1. Treatments 1 and 2 as for Bud moth. See also under "Plum."

BORERS:

1. Cut out those already in the tree, in May.
2. Wrap several thicknesses of paper around the trunk and fasten, about the first of June, and leave till September; cover upper part of trunk and larger limbs with whitewash and a little Paris green, at the same time. See report of Department for 1898.

OYSTER-SHELL SCALE AND SCURFY SCALE:

1. If severe, scrape the parts affected or spray with Whale Oil Soap before buds swell in spring.
2. Spray about the 5th of June, with Kerosene Emulsion.
3. Repeat 2 about June 25th. See Bulletin 43 of Department.

SAN JOSE SCALE:

See under "Peach."

SCAB:

1. Spray with Bordeaux mixture and Paris green just before the blossoms open.
2. Repeat 1 as soon as blossoms have fallen.
3. Repeat 1 about ten days later, and 4, if necessary two weeks later.

BITTER-ROT.

Same treatment as for Scab.

APPLE LEAF RUST:

1. Destroy all Red Cedar trees in the neighborhood of the orchard as this fungus passes a part of its life on the Cedars, causing the "Cedar Apples."

Apricot.

See Peach.

Asparagus.

ASPARAGUS BEETLES:

1. Destroy all volunteer asparagus, leaving only the shoots designed for market.
2. Let fowls run among the plants.
3. If serious, dust with fresh-dry-slacked lime while dew is on.
4. Repeat 3 every other day of ten days.

Bean.

ANTHRACNOSE OR POD SPOT:

1. Spray with Bordeaux mixture when first true leave has formed.
2. Repeat 1 often enough to keep leaves covered by the mixture till a week before eating pods.
3. Soaking the seed before planting, in ammoniated copper carbonate for an hour is a very effectual treatment.

LIMA BEAN MILDEW:

1. Burn all parts of the plant at once after harvesting the crop.

Beet.

RUST:

1. Spray with Bordeaux mixture as soon as it appears.
2. Remove and burn all affected leaves.

LEAF SPOT:

1. Use Bordeaux mixture when four leaves have appeared.
2. Repeat at intervals to keep the mixture on the leaves.
3. Burn the leaves as soon as the crop has been gathered.

Cabbage and Cauliflower.

APHIS:

1. Use Kerosene Emulsion when they appear.
2. Repeat when needed till plants begin to head.
3. After heading begins use hot water or tobacco water.

CABBAGE WORM:

1. Paris green or Arsenate of Lead when the caterpillars first appear.
2. Repeat about every ten days till heading begins.
3. After heading begins, use Kerosene emulsion or hot water as often as may be needed.
4. Fresh lime applied while dew is still on is also a good method.

ZEBRA CATERPILLAR:

1. Destroy the caterpillars as soon as they appear, while they are yet in company.
2. Use Paris green when needed, till the head begins to form, or the "flower" appears in the case of cauliflower.
3. Hand picking or hot water when poisons cannot be safely used. See Report of the Department for 1898.

ROOT MAGGOT:

1. When the maggots are first noticed, make a small hole near the main root of the plant, pour in half a teaspoonful of Carbon Disulphide, and close up the hole.
2. Tarred paper cut to let the plant grow up through the centre but fitting closely to the stem and onto the ground is a good preventative method. See Report of Department for 1898.

HARLEQUIN CABBAGE BUG:

A recent addition to cabbage foes in Pennsylvania. A hard black bug with red or orange markings, nearly half an inch long when full grown. 1. Plant a trap crop of mustard early for the bugs to collect on and gather them from this or spray it with pure kerosene. 2. Gather the bugs and egg masses by hand. See Report of Department for 1898.

CLUB-ROOT:

1. Burn affected plants.
2. Strict rotation of crops.
3. Lime, 75 bushels to the acre, has been highly recommended as a preventive.

Carnation.**ANTHRACNOSE AND RUST:**

1. Bordeaux mixture on first appearance.
2. Repeat every two weeks till flowers appear.
3. After flowers appear, use ammoniacal copper carbonate every two weeks.

Celery.**CELERY CATERPILLAR:**

1. Paris green while plants are small.
2. Later, hand picking if necessary.

BLIGHT OR RUST:

1. Ammoniacal copper carbonate.
2. Repeat once a week.
3. Artificial shade is advantageous.

LEAF-BLIGHT:

Same as for Rust.

SOFT-ROT:

Chiefly in plants stored or banked in wet places. 1. Keep dry, Or 2. Place under pure water.

Cherry.**APHIS:**

1. Kerosene Emulsion when they first appear.
2. Repeat every three or four days, if necessary.

SLUG:

1. Paris green or Arsenate of Lead.
2. Repeat if needed every ten or twelve days.

CURCULIO:

See under "Plum."

BLACK KNOT:

1. Cut off the branches six inches or more below the injured place and burn them.
2. Get your neighbors to do the same to their trees. United action is necessary if the disease is to be stamped out.

ROT:

1. Bordeaux mixture before blossoms open. The addition of Paris green at this time is a good plan.
2. Repeat, without Paris green, when the fruit has set.
3. Repeat 2 twice at intervals of one to two weeks.

LEAF BLIGHT:

Same as for Rot.

Chrysanthemum.**LEAF-SPOT:**

1. Bordeaux mixture on first appearance.
2. Repeat every two weeks if needed.

Corn.**WIRE-WORMS:**

1. Rotation of crops.
2. Late fall plowing, repeated for several years.
3. Kainit, 1,000 pounds per acre has been highly recommended. See Report of Department for 1898.

CUT-WORMS:

1. Trap by scattering bunches of fresh clover, dipped in Paris green over the field before planting.
2. Place such bunches along the rows, later. Caution: Keep fowls and stock away.

CORN WORM OR BOLL WORM:

1. Hand picking.
2. Late fall plowing. See Report of Department for 1898.

SMUT:

1. Cut out and burn all portions affected, as soon as discovered.

Cucumber and Squash.**STRIPED CUCUMBER BEETLE:**

1. Netting till plants are well established or,
2. Powdered refuse tobacco around the stems, occasionally renewed. See Report of Department for 1898.

SQUASH BUG:

1. Burn vines immediately after gathering the crop.
2. Hand picking.

MILDEW: ,

1. Bordeaux mixture on first appearance.
2. Burn vines after gathering the crop.

Currant and Gooseberry.**CURRANT WORM:**

1. Paris green or Hellebore when the worms first appear.
2. Repeat, using Hellebore every ten days or two weeks if needed.

STEM GIRDLER:

1. Cut off stem three inches below the girdled place and burn.

GOOSEBERRY FRUIT WORM:

1. Let fowls run among the plants.
2. Pick off and destroy injured fruit.
3. Rake up and burn the fallen leaves and rubbish near by, in the fall.

FOUR-LINED LEAF BUG:

1. Spray with Kerosene Emulsion one part; water five parts, in May.

LEAF-SPOT:

1. Spray with ammoniacal copper carbonate soon after leaves open.
2. Repeat with Bordeaux mixture every two weeks as long as needed.
3. Gather and burn fallen leaves in the fall.

MILDEW:

1. Spray with Potassium Sulphide solution (liver of sulphur) as the leaves begin to open.
2. Repeat every two to three weeks if needed.

Egg Plant.**LEAF-SPOT:**

1. Bordeaux mixture as soon as plants are established in the field.
2. Repeat every two or three weeks till fruit is half grown.
3. Then use ammoniated copper carbonate.

Elm.**ELM LEAF BEETLE:**

1. Spray with Paris green or Arsenate of Lead when leaves first open.
2. Repeat two weeks later.
3. Repeat if necessary.

TUSsock Moth: .

1. Gather and destroy the whitish egg masses in winter.
2. Repeat in July or August, before the eggs hatch and the caterpillars scatter.
3. If the caterpillars are feeding, spray with Paris green or Arsenate of Lead as often as needed.

Grape.

ROSE BUG:

1. Collect the insects by hand. 2. Bag the forming bunches of grapes. See Report of Department for 1898.

GRAPE-VINE FLEA BEETLE:

1. Spray with Paris green or Arsenate of Lead as soon as seen. 2. Repeat every week if necessary.

GRAPE-VINE LEAF HOPPER:

1. Dust the vines with insect powder or tobacco dust about the first of July. 2. Repeat one week later if necessary.

ANTHRACNOSE:

1. Brush the vines over with Sulphate of Iron and Sulphuric Acid solution before the buds open. 2. Repeat three or four days later. Do not use after the vines start growing.

DOWNY MILDEW, POWDERY MILDEW:

1. Bordeaux mixture when leaves are fully opened. 2. Repeat about ten days before the flowers open. 3. Spray with potassium sulphide solution three weeks later if necessary.

BLACK ROT:

1. Bordeaux mixture as the buds open. 2. Repeat every two weeks if needed, till fruit is half grown; then use ammoniacal copper carbonate, repeating every week or two if necessary.

RIPE ROT:

1. Same treatment as 2 under black rot.

Hollyhock.

RUST:

1. Bordeaux mixture as leaves open. 2. Repeat at intervals of ten days if needed.

Maples.

TUSSOCK MOTH:

See under "Elm."

COTTONY MAPLE SCALE:

1. Spray with Kerosene Emulsion early in June. 2. Repeat in two weeks if necessary.

Nursery Stock.

SUCKING INSECTS:

1. Kerosene emulsion as soon as discovered. 2. Repeat in two weeks if necessary.

CHEWING INSECTS:

1. Paris green or Arsenate of Lead when discovered.
2. Repeat as may be needed.

FUNGIOUS DISEASES:

1. Bordeaux mixture when leaves open.
2. Repeat every two weeks if needed.

Oats.

LOOSE SMUT:

- Soak the seed five to ten minutes in hot water at 133 degrees F. This may be done some time before planting, if desired, and hastens sprouting besides destroying the Smut.

RUST:

No good treatment known.

MAGGOT:

1. Put the onion bed some distance from the one of the preceding year.
2. Same treatment as for the cabbage root maggot.

MILDEW:

1. Burn all the tops in the fall.
2. Rotation of crops.

SMUT:

1. Burn all refuse in the fall.
2. Start the onions on land not used for onions the preceding year and transplant—a process which pays for other reasons also.

Peach, Apricot, Nectarine.

PEACH BORER:

1. Wrapping trunk as described for Apple tree Borer.
 2. Mounding up earth a foot or more about June 1st, and removing about September 1.
 3. Wash trunk and lower parts of limbs with whitewash and a little glue, with a tablespoonful of Paris green to each bucketful.
 4. Cut out borers already in the tree.
- 1, 2 and 3 are alternate methods of treatment. See Report of Department for 1898.

BLACK PEACH APHIS:

1. Dig refuse tobacco powder or stems, or Kainit into the ground about the roots.
2. Spray with Kerosene Emulsion when the Aphis appears above the ground.

CURCULIO:

See under "Plum."

SAN JOSE SCALE:

1. Keep trunk and limbs covered with whitewash from June 1st. till frost appears.
2. Spray with Whale oil Soap, 1 lb. to 1 gal-

lon of water, after the leaves are off in the fall. 3. Spray with Whale oil Soap, 2 lbs to 1 gallon of water, before the buds start in the spring. 4. Cut back and thoroughly prune infested trees after spraying and burn the prunings. 5. Destroy badly infested plants. See Bulletin No. 43 of Department.

PEACH LEAF CURL:

1. Spray with Copper Sulphate before buds open in spring.
2. Spray with Bordeaux mixture when leaves are half grown.

PEACH ROSETTE:

No good remedy.

BROWN ROT:

1. Spray with Copper Sulphate before buds open.
2. Bordeaux mixture before flowers open.
3. Repeat 2 every ten to fourteen days after fruit has set, until the fruit is half grown.
4. Repeat every five to seven days, using ammoniacal copper carbonate instead of Bordeaux mixture.

YELLOW:

1. Destroy all affected trees by fire.
2. Dig out and burn roots also.

Pear.

BORERS:

See under Apple..

CODLING MOTH:

See under Apple..

PEAR MIDGE:

1. Apply 1,000 lbs. of Kainit per acre, to the ground beneath the trees about the middle of June.

PEAR LEAF MITE:

1. Spray in winter with Kerosene Emulsion, 1 part; water 6 parts.

PEAR PSYLLA.

1. Spray with Whale oil Soap, 1 lb. to 1 gal. of water, in April, spraying only the trunk and larger branches.

SLUG:

See under Cherry.

SAN JOSE SCALE:

See under Peach.

LEAF BLIGHT OR FRUIT-SPOT:

1. Spray with ammoniacal copper carbonate as the leaves open.
2. Bordeaux mixture just before the blossoms open.
3. Repeat 2 after fruit has set, at intervals of two weeks as needed.

FIRE BLIGHT:

Cut off and burn affected parts, cutting at least a foot below where the disease shows.

SCAB:

See under Apple..

Plum.**CURCULIO:**

1. Spray with Paris green or Arsenate of Lead before the flower buds open.
2. Repeat 1 soon after the blossoms have fallen.
3. Gather the insects by jarring onto cloths beneath the tree, at night and in the morning.
4. Gather and destroy fallen plums every day.
5. Let fowls run under the trees.

PLUM LECANIUM:

1. Kerosene emulsion one part, water four parts, after leaves have fallen in the fall.
2. Repeat 1 in spring before the buds open.

SLUG:

See under Cherry.

BORERS:

See under Apple..

SAN JOSE SCALE:

See under Peach.

LEAF BLIGHT:

1. Bordeaux mixture when the leaves first appear.
2. Repeat 1 after the fruit has set, every two or three weeks till fruit is three-quarters grown.
3. Now use ammoniacal copper carbonate if needed, every two or three weeks.

BROWN ROT:

See under Peach.

BLACK KNOT:

See under Cherry.

Potato.**POTATO BEETLE:**

1. Paris green or Arsenate of Lead as soon as insects are seen.
2. Repeat whenever needed.

POTATO STALK BORER:

1. Gather and burn all stalks after gathering the crop.

EARLY BLIGHT OR LEAF SPOT:

1. Bordeaux mixture when plants are half grown.
2. Repeat 1 every two or three weeks.

POTATO ROT:

1. Bordeaux mixture about the middle of July.
2. Repeat 1 every two weeks.

SCAB:

Soak seed potatoes in corrosive sublimate 1 ounce, water 8 gallons, for one and one-half hours before cutting them.

LATE BLIGHT OR MILDEW:

1. Bordeaux mixture when the disease appears.
2. Repeat 1 whenever needed.

Quince.

CURCULIO:

1. Jarring as for Plum Curculio.

LEAF BLIGHT:

1. Bordeaux mixture before flower buds open.
2. Repeat 1 when fruit has set, and every two or three weeks until fruit is three-quarters grown.
3. Ammoniacal copper carbonate later, if needed.

FIRE BLIGHT:

See under Pear.

Raspberry, Blackberry, Dewberry.

SLUG:

1. Paris green or Arsenate of Lead when insects first appear.
2. Repeat 1 two weeks later unless fruit is nearly ripe.

SNOWY TREE-CRICKET:

Cut off and burn twigs pierced, during the winter, to destroy the eggs in them.

ANTHRACNOSE:

1. Cut out all badly diseased canes.
2. Copper Sulphate solution before the buds open.
3. Bordeaux mixture after growth has commenced.
4. Repeat 3 every two or three weeks till fruit is two-thirds ripe.

CRANGE RUST:

1. Cut out and burn all diseased plants.
2. Get your neighbors to do the same.

Rose.

APHIS AND LEAF HOPPERS:

1. Kerosene Emulsion, strong soad suds or tobacco water as often as needed.

SLUGS:

Dust with quick lime.

RED SPIDER:

Syringe with clear water. If very abundant, Kerosene emulsion.

BLACK SPOT:

Spray once a week with ammoniacal copper carbonate.

MILDEW:

1. Spray with Bordeaux mixture or ammoniacal copper carbonate as often as necessary.
2. In greenhouses, fumigation with sulphur.

RUST:

1. Destroy all affected portions.
2. Gather and burn dead leaves in the fall.
3. Ammoniacal copper carbonate after leaves open.

Strawberry.

SLUG:

See under Raspberry.

WEEVIL:

No good remedy.

LEAF BLIGHT:

1. Bordeaux mixture after the crop is gathered.
2. Repeat 1 when leaves open in the spring.
3. Repeat 2 just before blossoms open.

Tomato.

TOMATO WORM:

1. Hand picking.
2. Paris green or Arsenate of Lead, as needed, till fruit begins to turn in color.

CORN WORM:

See under Corn.

FLEA BEETLE:

Paris green or Arsenate of Lead as often as needed.

LEAF BLIGHT:

1. Bordeaux mixture as soon as disease is discovered.
2. Repeat 1 every week or ten days.

ROT:

Same treatment as for Leaf Blight.

Violet.

RED SPIDER:

See under Rose.

BLIGHT SPOT:

Bordeaux mixture when disease appears. Repeat every ten days when blossoms are not present. 3. Remove affected leaves.

Wheat.**HESSIAN FLY:**

1. Plant a trap piece about August 1st. 2. Plow under about September 10th, and plant main crop after Sept. 20th. See report of Department for 1898.

WHEAT MIDGE:

1. Plow deep soon after harvest. 2. Carefully sweep up and burn chaff and "tailings" after threshing. See Report of Department for 1898.

APHIS:

No good treatment. See Report of Department for 1898.

FORMULAS.**PARIS GREEN.**

	Parts.	Per bbl.
Paris green,	1 lb.	$\frac{1}{4}$ lb.
Quick lime,	1 lb.	$\frac{1}{4}$ lb.
Water,	200 gals.	50 gals.

This is too strong for the peach, where $2\frac{1}{2}$ oz. each of Paris green and quick lime should be used instead of $\frac{1}{4}$ lb. Keep the mixture well stirred while using. To make it, mix the Paris green and the lime and add enough of the water to slake the lime, stirring while hot, then add the rest of the water.

Good Paris green gives far better results than the cheaper grades.

ARSENATE OF LEAD.

This is a comparatively new insecticide, its value having only become known within a few years. It has several advantages over either Paris green or London purple, the chief ones being that it remains more easily suspended in water, thus requiring much less stirring up during the spraying; that it shows plainly on the leaves, indicating where the spray has reached, and where it has not; and that large proportions may be used without danger of burning the leaves. It is therefore especially useful where the leaves are particularly sensitive.

	Parts.	Per bbl.
Arsenate of soda,	4 oz.	2 oz.
Acteate of lead,	11 oz.	$5\frac{1}{2}$ oz.
Water,	100 gals.	50 gals.

These two substances, when placed in the water dissolve rapidly, and combine, forming a fine white sediment which is the Arsenate of Lead. It can also be purchased ready for addition to the water, but it is usually better when prepared as above. It is as cheap, or in the end cheaper than Paris green, as it stays much longer on the trees before being washed off by the rains. Some persons advise the addition of two quarts of molasses to each hundred gallons of the water, but the benefit to be derived from this is questionable.

WHALE OIL SOAP.

	Parts.	Per bbl.
Whale oil soap,	2 lbs.	80 lbs.
Water,	1 gal.	40 gals.

This is much stronger than Kerosene Emulsion and should only be used during winter, when the trees are not growing. It can be used for insects which cannot be killed by Kerosene Emulsion. In spraying for the San Jose Scale in the fall (see under Peach), it should be used at the rate of one pound to a gallon of water; in the spring before the buds open, or for winter work, it can be used as above given.

KEROSENE EMULSION.

	Parts.	Per bbl.
Hard soap (shaved fine),	$\frac{1}{2}$ lb.	1 lb.
Water,	1 gal.	2 gals.
Kerosene,	2 gals.	$3\frac{1}{2}$ gals.

Dissolve the soap in the water, which should be boiling, and while it is very hot pour the suds into the kerosene; then churn it with a spray pump till it changes to a creamy mass, and then to a soft, butter-like substance. This should keep for some time. When it is wished to use it, add one part of it to nine times as much water, mix well, and spray the plants. The water should be soft water, or else have some soda added to it.

For the Four-lined Leaf bug take one part of the Emulsion and five parts of water.

TOBACCO WATER.

Place tobacco stems or refuse tobacco in enough hot water to cover; let stand several hours. Take one part of this to three or four of water, and spray over the plants.

CARBON DISULPHIDE.

To be obtained of druggists at about thirty cents per pound. In

using, avoid bringing it near fire or even hot steam pipes as it catches fire easily. Avoid breathing it also.

HELLEBORE.

May be applied either as a powder or in water. If used as a powder it may advantageously be mixed with an equal amount of flour, which causes it to remain better on the leaves. For use with water one ounce of fresh Hellebore is mixed with three gallons of water.

INSECT POWDER.

Insect powder is sometimes sold under the names of Pyrethrum and Buhach. It may be applied as the dry powder, when the plant is wet with dew. It may also be mixed with flour and used in that way, or it may be used in an alcoholic solution as follows:

Insect powder (by weight),	1 part.
Alcohol (by weight),	4 parts.

Put the two in a tight vessel and leave there for eight days, shaking occasionally; then filter and spray over the plants.

It should be remarked that Insect Powder is only of value when fresh and full strength. Unfortunately it is difficult to obtain it fresh, and much of it is so adulterated as to be practically worthless.

LIME.

Lime is often of much value as an insecticide, either as whitewash, sometimes with enough Paris green added, to give it a slight greenish tinge, or as quick lime to be dusted onto the insects. When used in the preparation of Paris green it is added to combine with the free arsenic present, which would burn the leaves, if left uncombined.

NORMAL OR 1.6 PER CENT. BORDEAUX MIXTURE.

Copper sulphate (blue vitriol),	6 pounds.
Quick lime (good stone lime),	4 pounds.
Water,	50 gallons.

Dissolve the copper sulphate by putting it in a bag of coarse cloth and hanging this in a vessel containing 4 to 6 gallons of water. Use an earthen or wooden vessel. After the copper sulphate is dissolved, dilute with water to 25 gallons. Slake the lime and add 25 gallons of water. Mix the two and keep thoroughly stirred while using. If the mixture is to be used on peach foliage, it is advisable to add two pounds more of lime to the above formula.

BORDEAUX MIXTURE AND PARIS GREEN.

Mix 4 ounces of Paris green as prepared above, with 50 gallons of normal Bordeaux mixture.

AMMONIACAL COPPER CARBONATE.

Copper carbonate,	4 ounces.
Ammonia,	3 pints.
Water,	45 gallons.

Make a paste of the copper carbonate with a little of the water. Dilute the ammonia with 7 or 8 times its bulk of water. Add the paste to the diluted ammonia and stir until dissolved. Add enough water to make up to the 45 gallons. Let it settle and use the clear blue liquid only. Do not make this up long before using as it loses its strength on standing. It is used when the fruit is so nearly ripe that Bordeaux mixture would produce stains if it were used.

POTASSIUM SULPHIDE SOLUTION.

(Liver of Sulphur.)

Potassium sulphide,	$\frac{1}{2}$ to 1 ounce.
Water,	1 gallon.

Particularly good for surface mildews but loses its strength upon standing, so should be used at once after making.

SULPHATE OF IRON AND SULPHURIC ACID SOLUTION.

Water (hot),	100 parts.
Iron sulphate (green vitriol),	as much as the water will dissolve.
Sulphuric acid (commercial),	1 part.

Make the mixture with much care, as heat is produced. Use on plants when dormant only, applying with brushes or sponges, as the solution is injurious to spraying machinery.

CORROSIVE SUBLIMATE.

This dissolves slowly and but slightly in water. The process may be hastened by heating the water.

GENERAL REMARKS.

In the treatment of fruits by sprays it should be remembered that the substances used are in almost every case poisonous. It is accordingly necessary to avoid spraying at times when fruit is nearly

ripe, both on account of the possibility of placing poison on the fruit just before it is picked, and because of the danger of staining it, as would be the case if certain solutions were used.

Spraying solutions often need to be carefully strained, and it is advisable to do this when putting them into the barrel or other receptacle from which they will pass through the spray pump. Nozzles will clog from larger lumps in the fluid, and care should be taken to avoid this as far as possible. Every pump should have an agitator attached to keep the mixture well stirred in the barrel, and it should not be expected that the same nozzle will do first class work with every spraying mixture given. Some nozzles are especially adapted to one kind of spray, and others to other sprays. Above all, an intelligent knowledge of what is causing the injury, and exactly how and when to take the proper steps to control it, should be one of the ingredients added to every formula here given.

FIFTY DAIRY RULES.

From the Report of the Bureau of Animal Industry of the United States in 1898.

The Owner and His Helpers.

1. Read current dairy literature and keep posted on new ideas.
2. Observe and enforce the utmost cleanliness about the cattle, their attendants, the stable, the dairy, and all utensils.
3. A person suffering from any disease, or who has been exposed to a contagious disease, must remain away from the cows and the milk.

The Stable.

4. Keep dairy cattle in a room or building by themselves. It is preferable to have no cellar below and no storage loft above.
5. Stables should be well ventilated, lighted, and drained; should have tight floors and walls and be plainly constructed.
6. Never use musty or dirty litter.
7. Allow no strongly smelling material in the stable for any length of time. Store the manure under cover outside the cow stable and remove it to a distance as often as practicable.
8. Whitewash the stable once or twice a year. Use land plaster in the manure gutters daily.
9. Use no dry, dusty feed just previous to milking; if fodder is dusty, sprinkle it before it is fed.
10. Clean and thoroughly air the stable before milking. In hot weather sprinkle the floor.
11. Keep the stable and dairy room in good condition, and then insist that the dairy, factory, or place where the milk goes be kept equally well.

The Cows.

12. Have the herd examined at least twice a year by a skilled veterinarian.
13. Promptly remove from the herd any animal suspected of being in bad health and reject her milk. Never add an animal to the herd until certain it is free from disease, especially tuberculosis.
14. Do not move cows faster than a comfortable walk while on the way to place of milking or feeding.
15. Never allow the cows to be excited by hard driving, abuse, loud

talking, or unnecessary disturbance; do not expose them to cold or storm.

16. Do not change the feed suddenly.

17. Feed liberally, and use only fresh, palatable feed stuffs; in no case should decomposed or moldy material be used.

18. Provide water in abundance, easy of access, and always pure; fresh, but not too cold.

19. Salt should always be accessible.

20. Do not allow any strong-flavored food, like garlic, cabbage, and turnips, to be eaten, except immediately after milking.

21. Clean the entire body of the cow daily. If hair in the region of the udder is not easily kept clean it should be clipped.

22. Do not use the milk within twenty days before calving nor within three to five days afterwards.

Milking.

23. The milker should be clean in all respects; he should not use tobacco; he should wash and dry his hands just before milking.

24. The milker should wear a clean outer garment; used only when milking, and kept in a clean place at other times.

25. Brush the udder and surrounding parts just before milking, and wipe them with a clean, damp cloth or sponge.

26. Milk quietly, quickly, cleanly and thoroughly. Cows do not like unnecessary noise or delay. Commence milking at exactly the same hour every morning and evening, and milk the cows in the same order.

27. Throw away (but not on the floor, better in the gutter) the first few streams from each teat; this milk is very watery and of little value, but it may injure the rest.

28. If in any milking a part of the milk is bloody or stringy or unnatural in appearance, the whole mess should be rejected.

29. Milk with dry hands; never allow the hands to come in contact with the milk.

30. Do not allow dogs, cats, or loafers to be around at milking time.

31. If any accident occurs by which a pail full or partly full of milk becomes dirty, do not try to remedy this by straining, but reject all this milk and rinse the pail.

32. Weigh and record the milk given by each cow, and take a sample morning and night, at least once a week, for testing by the fat test.

Care of Milk.

33. Remove the milk of every cow at once from the stable to a clean, dry room, where the air is pure and sweet. Do not allow cans to remain in stables while they are being filled.

34. Strain the milk through a metal gauze and a flannel cloth or layer of cotton as soon as it is drawn.

35. Aerate and cool the milk as soon as strained. If an apparatus for airing and cooling at the same time is not at hand, the milk should be aired first. This must be done in pure air, and it should then be cooled to 45 degrees if the milk is for shipment, or to 60 degrees if for home use or delivery to a factory.

36. Never close a can containing warm milk which has not been aerated.

37. If cover is left off the can, a piece of cloth or mosquito netting should be used to keep out insects.

38. If milk is stored, it should be held in tanks of fresh, cold water (renewed daily), in a clean, dry, clad room. Unless it is desired to remove cream, it should be stirred with a tin stirrer often enough to prevent forming a thick cream layer.

39. Keep the night milk under shelter so rain can not get into the cans. In warm weather hold it in a tank of fresh cold water.

40. Never mix fresh warm milk with that which has been cooled.

41. Do not allow the milk to freeze.

42. Under no circumstances should anything be added to milk to prevent its souring. Cleanliness and cold are the only preventatives needed.

43. All milk should be in good condition when delivered. This may make it necessary to deliver twice a day during the hottest weather.

44. When cans are hauled far they should be full, and carried in a spring wagon.

45. In hot weather cover the cans, when moved in a wagon, with a clean wet blanket or canvass.

The Utensils.

46. Milk utensils for farm use should be made of metal and have all joints smoothly soldered. Never allow them to become rusty or rough inside.

47. Do not haul waste products back to the farm in the same cans used for delivering milk. When this is unavoidable, insist that the skim milk or whey tank be kept clean.

48. Cans used for the return of skim milk or whey should be emptied and cleaned as soon as they arrive at the farm.

49. Clean all dairy utensils by first thoroughly rinsing them in warm water; then clean inside and out with a brush and hot water in which a cleaning material is dissolved; then rinse and lastly sterilize by boiling water or steam. Use pure water only.

50. After cleaning, keep utensils inverted, in pure air, and sun if possible, until wanted for use.

AVERAGE COMPOSITION OF FEEDING STUFFS.

Taken from Bulletin No. 16, Prepared by Enos H. Hess, of the State Experiment Station, State College, Pa.

The following table is taken from "Rational Stock Feeding," by H. P. Armsby, with a few additions from the New Jersey report of 1894:

"The figures for the percentage composition are taken, in nearly every case, from the compilations of analysis of American feeding stuffs prepared by Drs. Jenkins and Winton, of the Connecticut Station, for the Office of Experiment Stations of the United States Department of Agriculture. The figures for the percentages of digestible matter, contained in the last five columns of the table, have been calculated from the average results of American digestion experiments, as compiled by Director Jordan of the Maine Station for the Office of Experiment Stations. In those cases in which no American results were available, the average results of German digestion experiments have been used and in cases where no results were available the digestibility has been estimated from that of other feeding stuffs of similar composition and properties. These latter cases are distinguished by being enclosed in parenthesis in the table.

"Under percentages of digestible matter are given, first, the percentages of digestible protein, carbohydrates and fat; second, in the column headed 'total,' the percentage of total digestible matter reduced to its 'starch equivalent.' A pound of fat has been shown to be about two and one-fourth times as valuable as a pound of carbohydrates for the production of heat or force in the body; consequently the percentage of fat has been multiplied by two and one-fourth and the percentages of carbohydrates and protein, added to give the figures under the heading of 'total' in the next to the last column of the table. By the nutritive ratio of a feeding stuff is meant the ratio of digestible protein to other digestible matter, the latter having been reduced to its starch equivalent. Thus, the first feeding stuff given in the table contains 1.1 per cent. of digestible protein and 12.3 per cent. of total digestible matter calculated to its starch equivalent. Subtracting the 1.1 per cent. of protein, we have left 11.2 per cent. of other digestible matters, consequently the ratio of digestible protein to other digestible matters is 1.1:11.2, or 1:10.2, as given in the last column of the table.

Average Composition of Feeding Stuffs.—Continued.

	Number of analyses.	Percentage Composition.						Per cent. of Digestible Matter.					Nutritive ratio.
		Water.	Ash.	Protein.	Crude fibre.	Nitrogen-free extract.	Fat.	Protein.	Carbohydrates.	Fat.	Total†		
<i>Selling Fodder.</i>													
Corn—dent, cut before glazing,	54	79.7	1.2	1.7	5.4	11.5	0.5	1.1	11.8	0.4	13.8	1:11.5	
Cow pea,	10	83.6	1.7	2.4	4.8	7.1	0.4	1.6	7.0	0.3	9.1	1: 4.7	
Crimson clover (just heading),†	2	89.2	1.2	2.5	1.8	4.9	0.4	1.7	4.4	0.2	6.6	1: 2.9	
Crimson clover (full bloom),†	6	81.5	1.5	3.2	5.1	8.1	0.6	2.2	8.2	0.3	11.1	1: 4.1	
Oats,	5	62.2	2.5	3.4	11.2	19.3	1.4	(2.7)	(22.3)	(1.0)	(27.3)	(1: 9.1)	
Orchard grass (in bloom),†	4	73.0	2.0	2.6	8.2	13.3	0.9	1.8	15.5	0.6	18.7	1: 9.4	
Pasture grass,†	17	70.3	2.8	4.7	6.5	14.5	1.2	3.5	16.2	0.8	21.5	1: 5.2	
Red clover,	43	70.8	2.1	4.4	8.1	13.5	1.1	3.0	13.3	0.7	17.9	1: 5.0	
Rye,	6	82.0	1.6	2.4	4.8	8.5	0.7	1.9	9.8	0.5	12.8	1: 5.7	
Soja bean,	6	74.8	2.4	3.0	7.3	11.5	1.0	(2.3)	(10.0)	(0.7)	(13.9)	(1: 5.0)	
<i>Silage.</i>													
Corn silage—kernels glazing or more mature,	14	72.1	1.4	2.1	6.7	16.4	1.3	1.1	15.7	1.1	19.3	1:16.5	
Red clover,	5	72.0	2.6	4.2	8.4	11.6	1.2	(2.8)	(3.5)	(0.8)	(18.1)	(1: 5.5)	
<i>Hay, Straw, Etc.</i>													
Alfalfa hay,	21	8.4	7.4	14.3	25.0	42.7	2.2	10.4	40.5	1.1	53.4	1: 4.1	
Corn fodder—field cured,	35	42.2	2.7	4.5	14.3	34.7	1.6	2.5	33.4	1.2	38.6	1:14.4	
Corn stover†—field cured,	60	40.1	3.4	3.8	19.7	31.9	1.1	2.0	33.4	0.6	36.8	1:17.4	
Clover hay—red, ..	38	15.3	6.2	12.3	24.8	38.1	3.3	6.4	34.9	1.6	44.9	1: 6.0	
Hungarian grass hay,†	12	7.7	6.0	7.5	27.7	49.0	2.1	4.2	46.7	1.0	53.2	1:11.4	
Mixed meadow grass hay,†	11	16.0	4.6	6.4	29.9	41.0	2.1	3.6	42.9	1.0	48.8	1:12.6	
Mixed hay,	14.3	5.3	9.1	26.9	41.5	2.9	4.7	39.3	1.5	47.4	1: 9.1		
Oat straw,	12	9.2	5.1	4.0	37.0	42.4	2.3	1.4	43.9	0.9	47.3	1:22.8	
Orchard grass hay,	10	9.9	6.0	8.1	32.4	41.0	2.6	4.8	42.0	1.4	50.0	1: 9.4	
Red top hay,	9	8.9	5.2	7.9	28.6	47.5	1.9	4.8	46.9	1.0	54.0	1:10.3	
Rye straw,	7	7.1	3.2	3.0	38.9	46.6	1.2	0.6	40.6	0.4	43.1	1:69.2	
Timothy hay,	68	13.2	4.4	5.9	29.0	45.0	2.5	2.9	43.7	1.4	49.8	1:16.2	
Wheat straw,	7	9.6	4.2	3.4	33.1	43.4	1.3	0.6	38.2	0.5	39.9	1:65.5	
<i>Roots and Tubers.</i>													
Carrots,	8	88.6	1.0	1.1	1.3	7.6	0.4	(0.9)	(8.2)	(0.3)	(9.8)	(1: 9.9)	
Mangel wurzels, ..	9	50.9	1.1	1.4	0.9	5.5	0.2	1.1	5.4	.....	6.5	1: 4.9
Potatoes,	12	78.9	1.0	2.1	0.6	17.3	0.1	0.9	15.7	.....	16.6	1:17.4
Rutabagas,	4	88.6	1.2	1.2	1.3	7.5	0.2	1.0	8.1	0.2	9.5	1: 8.5	
Sugar beets,	19	86.5	0.9	1.8	0.9	9.8	0.1	1.6	10.7	0.1	12.5	1: 6.8	
Turnips,	3	90.5	0.8	1.1	1.2	6.2	0.2	1.0	7.2	0.2	8.7	1: 7.7	
<i>Grain.</i>													
Barley,	10	10.9	2.4	12.4	2.7	69.8	1.8	8.7	65.6	1.6	77.9	1: 8.0	
Buckwheat,	8	12.6	2.0	10.0	3.7	64.5	2.2	(7.8)	(50.7)	(1.8)	(62.6)	(1: 7.0)	
Corn—dent,	86	10.6	1.5	10.3	2.2	70.4	5.0	6.2	64.8	4.6	81.4	1:12.1	
Corn—flint,	68	11.3	1.4	10.5	1.7	70.1	5.0	6.3	54.5	4.6	81.2	1:11.9	
Corn—sweet,	26	8.3	1.9	11.6	2.8	66.8	8.1	7.0	61.5	7.5	85.4	1:11.2	
Oats,	30	11.0	3.0	11.8	9.5	59.7	5.0	9.2	47.3	2.8	62.4	1: 5.8	
Peas,	14.4	2.7	22.6	5.4	53.0	1.9	18.8	51.2	1.0	72.3	1: 2.8		
Rye,	6	11.6	1.9	10.6	1.7	72.5	1.7	(6.4)	(66.7)	(1.6)	(76.7)	(1:11.0)	
Sorghum seed,	10	12.7	2.1	9.0	2.6	70.0	3.6	(5.4)	(64.4)	(3.3)	(72.2)	(1:13.3)	
Wheat—spring,	13	10.4	1.9	12.5	1.8	71.2	2.2	(7.5)	(66.5)	(2.0)	(77.5)	(1: 9.3)	
Wheat—winter,	262	10.5	1.8	11.8	1.8	72.0	2.1	(7.1)	(66.2)	(1.9)	(77.6)	(1: 9.9)	

Average Composition of Feeding Stuff.—Continued.

	Number of analyses.	Percentage Composition.						Percent. of Digestible Matter.				Nutritive ratio.
		Water.	Ash.	Protein.	Crude fibre.	Nitrogen-free extract.	Fat.	Protein.	Carbohydrates.	Fat.	Total.†	
Wheat — winter raised in Pennsylvania,	41	10.7	1.6	11.8	1.7	72.2	2.0	(7.1)	(66.4)	(1.8)	(77.6)	1: 9.9
<i>Mill Products.</i>												
Barley meal,	3	11.9	2.6	10.5	6.5	66.3	2.2	7.4	64.3	2.0	76.2	1: 9.3
Corn meal,	77	15.0	1.4	9.2	1.9	68.7	3.8	5.5	63.2	3.5	76.6	1:12.9
Corn-and-cob meal,	7	15.1	1.5	8.5	6.6	64.8	3.5	4.4	60.0	2.9	70.9	1:15.1
Peal meal,	2	10.5	2.6	20.2	14.4	51.1	1.2	16.8	51.7	0.6	69.9	1: 3.2
Rye bran,	7	11.6	3.6	14.7	3.5	63.8	2.8	(11.5)	(44.3)	(2.0)	(60.3)	(1: 4.2)
Wheat bran,	88	11.9	5.8	15.4	9.0	58.9	4.0	12.0	38.9	2.9	57.4	1: 3.8
Wheat middlings, ..	32	12.1	3.3	15.6	4.6	60.4	4.0	12.8	53.2	3.4	73.7	1: 4.8
Wheat shorts,	12	11.8	4.6	14.9	7.4	56.8	4.5	12.2	50.0	3.8	70.8	1: 4.8
<i>By-Product and Waste Material.</i>												
Apple pomace,	7	76.7	0.5	1.4	3.9	16.2	1.3	(1.1)	(16.4)	.....	(17.5)	(1:14.9)
Brewers' grains—dried,	3	8.2	3.6	19.9	11.0	51.7	5.6	15.7	36.3	5.1	63.5	1: 3.0
Brewers' grains—wet,	15	75.7	1.0	5.4	3.8	18.5	1.6	4.3	9.4	1.5	17.1	1: 3.0
Buckwheat middlings,	3	13.2	4.8	23.9	4.0	42.0	7.1	(23.7)	(37.0)	(6.0)	(74.2)	(1: 2.1)
Cerealine food,†	3	9.6	2.6	10.6	6.8	62.3	8.1	9.0	53.4	6.6	77.3	1: 7.8
Corn oil meal,	3	9.0	2.4	24.8	6.7	43.6	13.5	21.1	38.2	10.9	83.8	1: 3.1
Corn cobs,	18	10.7	1.4	2.4	30.1	54.9	0.5	0.4	52.5	0.3	53.6	1:33.0
Cotton seed hulls, ..	4	10.4	2.6	4.0	44.4	36.6	2.0	0.4	31.5	1.5	35.3	1:37.3
Cotton seed meal, ..	35	8.2	7.2	42.3	5.6	23.6	13.1	37.2	15.1	12.7	90.9	1: 1.2
Gluten meal,	32	9.9	0.7	29.4	1.6	52.4	6.3	25.6	47.7	5.5	85.7	1: 2.4
Buffalo gluten meal,	1	7.8	1.0	21.8	6.7	52.7	10.0	18.5	45.6	8.1	82.3	1: 3.4
Chicago gluten meal,	1	11.1	1.2	35.1	0.7	45.0	6.9	30.5	41.0	6.1	85.2	1: 1.8
Cream gluten meal, ..	1	8.1	1.2	38.4	3.3	32.8	16.2	33.4	29.8	14.3	95.4	1: 1.9
Grano gluten feed,†	3	6.0	2.7	31.0	11.4	34.7	14.2	26.4	33.0	11.5	85.3	1: 2.3
Germ meal,†	1	29.6	11.1	21.7	2.9	45.8	29.6	(13.0)	(48.8)	(26.7)	(116.9)	.....
Linseed meal—new process,	14	10.1	5.8	33.2	9.5	38.4	3.0	28.9	38.8	2.7	73.8	1: 1.6
Linseed meal—old process,	21	9.2	5.7	32.9	8.9	35.4	7.9	29.3	32.7	7.0	77.8	1: 1.7
Malt sprouts,	4	10.2	5.7	23.2	10.7	48.5	1.7	18.6	36.5	1.7	58.9	1: 2.2
<i>Dairy Products.</i>												
Buttermilk,	24	91.8	0.8	2.8	.....	4.3	0.3	2.8	4.3	0.3	7.8	1: 1.8
Milk, .....	.....	87.3	0.7	3.1	.....	5.1	3.8	3.1	5.1	3.8	16.8	1: 4.4
Skim-milk,	303	90.5	0.8	3.5	.....	4.8	0.4	3.5	4.8	0.4	9.2	1: 1.6
Whey, .....	.....	93.0	0.8	0.8	.....	5.0	0.4	0.8	5.0	0.4	6.7	1: 7.4

†The fat reduced to its starch equivalent by multiplying by 2.25.

†Taken from the New Jersey report for 1894.

HOW TO COMPUTE A RATION.

The method of computing a ration is very simple if one knows how to do it, but "know how" is often very difficult to learn. It will be explained in as simple terms as possible in order that all who read carefully may learn how.

We will take a ration that contains 45 pounds ensilage, 5 pounds clover hay and 6 pounds buckwheat middlings. By referring to the table showing the composition of feeding stuffs, we find that these three foods contain the following amounts of digestible matter:

	Total dry matter.	Present Digestible Matter.			Nutritive ratio.
		Protein.	Carbohydrates.	Fat.	
Ensilage—kernels glazing or more matured,...	27.9	1.1	15.7	1.1	1:16.5
Clover hay—red,	84.7	6.4	34.9	1.6	1: 6.0
Buckwheat middlings,	86.8	(23.7)	(37.0)	(6.0)	(1: 2.1)

There is 72.1 per cent. of water in ensilage; to determine the amount of dry matter we subtract the amount of water it contains from 100, which leaves us 27.9 per cent. of dry matter. (See table.) The dry matter is obtained in this way for clover hay and buckwheat middlings or any other food you may wish to compute the analysis of.

The figures in the above table give the amount of digestible food in one pound of the different materials. In 45 pounds of ensilage there would be 45 times as much; in 5 pounds of clover hay there would be 5 times as much; and in 6 pounds of buckwheat middlings there would be 6 times as much digestible food as is given in the table. Multiplying these figures by 45, 5 and 6 respectively, we get the following:

	Fresh weight.	Total dry matter.	Protein.	Carbohydrates.	Fat.	Total digestible matter.	Nutritive ratio.
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.		
Ensilage,	45	19.56	.50	7.08	.50	8.08	.....
Clover hay,	5	4.24	.33	1.75	.08	2.15	.....
Buckwheat middlings,	6	5.21	1.43	2.23	.36	4.00	.....
Total,		22.01	2.24	11.05	.94	14.23	1: 5.9
Reduced for a cow weighing 1,000 pounds,		22.69	2.31	11.39	.97	14.23	1: 5.9
Wolf's German standard,		24.00	2.50	12.50	.40	15.40	1: 5.49

The cows receiving this ration are assumed to weigh 970 pounds. Other things being equal, the heavier the cow the more food she will need. The standard ration gives the amount of food required for a cow weighing 1,000 pounds. Therefore, in order to compare this ration with the standard it has to be reduced by dividing by .970. This quotient gives the amount of digestible food that would be required for a cow weighing 1,000 pounds on the same basis. It will be seen that it does not contain as much total dry matter, protein, carbohydrates and total digestible matter as the German standard; but more fat and the nutritive ratio is wider.

HOW TO CALCULATE THE NUTRITIVE RATIO AND TOTAL DIGESTIBLE MATTER.

If we burn a pound of coal we know that there is a certain amount of heat produced. If this heat be applied to water there will be a given quantity of the water converted into steam. Compress this steam and we get power by which we can run a threshing machine or lift a weight.

If we burn protein, carbohydrates or fat we will also get a certain amount of power if the heat is applied to water. We will assume that the burning of one pound of protein will produce enough power to lift one pound one foot from the ground. The carbohydrates have about the same power; but the power produced by burning one pound of fat is two and one-fourth times as great. That is to say, on the same basis, we multiply the amount of fat by two and one-fourth feet from the ground or two and one-fourth pounds one foot from the ground. In order to have the protein, carbohydrates and fat, if one pound of fat were burned it would lift one pound two and one-

fourth feet, and add this product to the amount of carbohydrates and divide the sum obtained, by the protein. The quotient will be the ratio. In the above ration there is .94 pound of fat. This multiplied by $2\frac{1}{4}$ equals 2.12 pounds; add to this amount the 11.05 pounds of carbohydrates and we have 13.17 pounds. Divide this amount by 2.24 (the amount of protein), and we get a quotient of 5.9, which equals the ratio of 1:5.9. That is to say, there is one pound of protein or milk and muscle forming food to 5.9 pounds of carbohydrates and fat or heat and fat forming foods.

AVERAGE PENNSYLVANIA PRICES FOR FEEDING STUFFS.

In a subjoined table is given as near as possible the average selling price of the different feeding stuffs for the past ten years. It was next to impossible to get figures for so long a time on some of the feeds. In these cases the present prices were taken. The cost of all the rations are based on the figures given in this table; in the case of hay, corn stover and other products of the farm the prices given are somewhat below the market price, and in the case of the by-products that have to be brought, the prices given are slightly higher than the market price. This was done in order to make allowance for the expense of hauling to or from the farm:

	Price per Ton.	Price per Lb.
Barley meal,	\$20 00	1.0
Brewers' grains (dry),	14 00	0.7
Buckwheat meal,	20 00	1.0
Buckwheat middlings,	18 00	.9
Cerealine food,	12 00	.6
Clover hay,	9 00	0.45
Corn-and-cob meal,	15 00	0.75
Corn meal,	19 00	0.95
Corn silage,	2 00	.1
Corn stover,	5 00	0.25
Cotton seed meal,	26 00	1.3
Gluten meal,	18 00	.9
Gluten meal,	18 00	0.90
Gluten meal (Buffalo),	18 00	.9
Gluten meal (Atlas),	18 00	.9
Green rye,	2 00	.1
Hominy meal,	14 00	.7
Linseed meal,	26 00	1.3
Malt sprouts,	22 00	1.1
Mangolds,	2 00	.1
Meadow hay,	11 00	0.55
Millet hay,	8 00	.4
Mixed hay,	10 00	.5
Oat meal,	22 00	1.1
Oat straw,	5 00	0.25
Potatoes,	5 00	0.25
Rutabagas,	3 00	0.15
Skimmed milk,	3 60	0.18
Timothy hay,	11 00	0.55
Wheat bran,	18 00	.9
Wheat chaff,	5 00	0.25
Wheat middlings,	19 00	0.95
Wheat shorts,	19 00	0.95
Wheat straw,	5 00	0.25

FEEDING STANDARDS.

From Bulletin No. 22, Department of Agriculture, Washington, D. C.

Attempts have been made to ascertain the food requirements of various kinds of farm animals under different conditions. Large number of feedings experiments have been made under varying conditions with this end in view. From the results, feeding standards have been worked out which show the amounts of digestible protein, fat, and carbohydrates supposed to be best adapted to different animals when kept for different purposes. The feeding standards of Wolff, a German, have been most widely used. They are as follows:

Wolff's Feeding Standards.

A.—Per Day and Per 1,000 Pounds Live Weight.

	Total organic matter.	Digestible Food Materials.			Fuel value.
		Protein.	Carbohydrates.	Fat.	
	Pounds.	Pounds.	Pounds.	Pounds.	Calories.
Oxen at rest in stall,	17.5	0.7	8.0	0.15	16,815
Wool sheep, coarser breeds,	20.0	1.2	10.3	0.20	22,235
Wool sheep, finer breeds,	22.5	1.5	11.4	0.25	25,050
Oxen moderately worked,	24.0	1.6	11.3	0.30	24,260
Oxen heavily worked,	26.0	2.4	13.2	0.50	31,126
Horses moderately worked,	22.5	1.8	11.2	0.60	26,712
Horses heavily worked,	25.5	2.8	13.4	0.80	33,508
Milch cows,	24.0	2.5	12.5	0.40	29,590
Fattening steers:					
First period,	27.0	2.5	15.0	0.60	34,660
Second period,	26.0	3.0	14.8	0.70	36,062
Third period,	25.0	2.7	14.8	0.60	35,082
Fattening sheep:					
First period,	26.0	3.0	15.2	0.50	35,962
Second period,	25.0	3.5	14.4	0.60	35,326
Fattening swine:					
First period,	36.0	5.0		27.5	60,450
Second period,	31.0	4.0		24.0	52,080
Third period,	23.5	2.7		17.5	37,570

B.—Per Day and Per Head.

	Average live weight per head.	Total organic matter.	Digestible Food Materials.			Fuel value.
			Protein.	Carbohydrates.	Fat.	
	Pounds.	Pounds.	Pounds.	Pounds.	Pounds.	Calories.
Growing cattle:						
Age—						
2 to 3 months,	150	3.3	0.6	2.1	0.30	5,116
3 to 6 months,	300	7.0	1.0	4.1	0.30	10,750
6 to 12 months,	500	12.0	1.3	6.8	0.30	16,332
12 to 18 months,	700	16.8	1.4	9.1	0.28	20,712
18 to 24 months,	850	20.4	1.4	10.3	0.26	22,859
Growing sheep:						
Age—						
5 to 6 months,	56	1.6	0.18	0.87	0.045	2,143
6 to 8 months,	67	1.7	0.17	0.85	0.040	2,066
8 to 11 months,	75	1.7	0.16	0.85	0.037	2,035
11 to 15 months,	82	1.8	0.14	0.89	0.032	2,051
15 to 20 months,	85	1.9	0.12	0.83	0.025	1,966
Growing fat swine:						
Age—						
2 to 3 months,	50	2.1	0.38		1.56	3,496
3 to 5 months,	100	3.4	0.50		2.50	5,580
5 to 6 months,	125	3.9	0.54		2.96	6,510
6 to 8 months,	170	4.6	0.58		3.47	7,533
8 to 12 months,	250	5.2	0.62		4.06	8,686

For an unworked ox of 1,000 pounds this standard calls for 0.7 pounds of digestible protein, 8 pounds of digestible carbohydrates, and 0.15 pounds of digestible fat, which would furnish 16,815 calories of heat and energy. When heavily worked the same ox would require, according to the standard, food with three times as much protein.

COMPOSITION OF FEEDING STUFFS.

Giving the Maximum, Minimum and Average for Each Ingredient.

From Farm Bulletin No. 22 of the Department of Agriculture, Washington, D. C.

The figures given do not represent the results of single analyses, but are the highest and lowest results which have been found in the case of each ingredient. *They are given to show the limits within which each ingredient has been found to vary.*

Composition of Feeding Stuffs.

	Water.	Ash.	Protein.	Fiber	Nitrogen-free extract.	Fat.	Number of analyses.
GREEN FODDER.							
Corn fodder:*	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	
Flint varieties—							
Minimum,	51.5	0.7	0.6	2.1	4.3	0.3	.....
Maximum,	90.8	1.8	4.0	11.4	36.3	1.3	.....
Average,	79.8	1.1	2.0	4.3	12.1	0.7	46
Flint varieties cut after kernels had glazed—							
Minimum,	69.7	0.9	1.5	3.0	10.0	0.6	.....
Maximum,	83.7	1.7	3.7	6.1	19.7	1.3	.....
Average,	77.1	1.1	2.1	4.3	14.6	0.8	10
Dent varieties—							
Minimum,	59.5	0.6	0.5	3.0	3.0	0.1	.....
Maximum,	93.6	2.5	3.3	11.0	27.0	1.6	.....
Average,	79.0	1.2	1.7	5.6	12.0	0.5	63
Dent varieties cut after kernels had glazed—							
Minimum,	59.5	1.0	1.0	5.4	11.6	0.4	.....
Maximum,	80.7	2.2	3.3	8.5	27.0	1.6	.....
Average,	73.4	1.5	2.0	6.7	15.5	0.9	7

*Corn fodder is the entire plant, usually a thickly planted crop. Corn stover is what is left after the ears are harvested.

Composition of Feeding Stuffs.—Continued.

	Water.	Ash.	Protein.	Fiber.	Nitrogen-free extract.	Fat.	Number of analyses.
GREEN FODDER—Continued.							
Sweet varieties—	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	
Minimum,	69.3	0.8	0.9	1.9	3.2	0.1	.....
Maximum,	92.9	2.6	2.7	8.5	19.4	1.0	.....
Average,	79.1	1.3	1.9	4.4	12.8	0.5	21
All varieties—							
Minimum,	51.5	0.6	0.5	1.9	3.0	0.1	.....
Maximum,	93.6	2.6	4.0	11.4	36.3	1.6	.....
Average,	79.3	1.2	1.8	5.0	12.2	0.5	128
Leaves and husks, cut green—							
Minimum,	57.9	2.1	1.8	6.6	16.7	1.0	.....
Maximum,	71.3	4.4	2.4	12.5	22.2	1.3	.....
Average,	66.2	2.9	2.1	8.7	19.0	1.1	4
Stripped stalks, cut green—							
Minimum,	74.5	0.6	0.4	6.7	14.2	0.4	.....
Maximum,	77.4	0.8	0.6	8.8	16.0	0.6	.....
Average,	76.1	0.7	0.5	7.3	14.9	0.5	4
Rye fodder:							
Minimum,	74.4	1.3	2.3	4.7	4.9	0.2	.....
Maximum,	84.3	2.4	3.0	14.9	12.4	0.7	.....
Average,	76.6	1.8	2.6	11.6	6.8	0.6	7
Oat fodder:							
Minimum,	31.3	1.5	1.5	7.1	10.8	0.4	.....
Maximum,	78.6	4.2	6.1	16.8	39.8	3.0	.....
Average,	62.2	2.5	3.4	11.2	19.3	1.4	6
Redtop,* in bloom:							
Minimum,	51.5	1.7	2.0	8.0	11.7	0.6	.....
Maximum,	76.2	2.9	4.3	15.7	21.9	1.1	.....
Average,	65.3	2.3	2.8	11.0	17.7	0.9	5
Tall oat grass,† in bloom:							
Minimum,	62.3	1.6	1.7	9.2	13.0	0.6	.....
Maximum,	73.5	3.0	3.3	9.7	20.7	1.5	.....
Average,	69.5	2.0	2.4	9.4	15.8	0.9	3
Orchard grass, in bloom:							
Minimum,	66.9	1.6	1.9	5.8	9.9	0.7	.....
Maximum,	77.3	2.9	4.1	11.1	16.6	1.3	.....
Average,	73.0	2.0	2.6	8.2	13.3	0.9	4
Meadow fescue, in bloom:							
Minimum,	67.6	1.6	1.8	10.2	12.5	0.7	.....
Maximum,	73.2	2.0	2.7	11.3	15.7	1.1	.....
Average,	69.9	1.8	2.4	10.8	14.3	0.8	4
Italian rye grass, coming into bloom:							
Minimum,	69.6	2.1	2.6	5.5	11.5	1.1	.....
Maximum,	76.6	2.8	3.8	7.5	15.4	1.6	.....
Average,	73.2	2.5	3.1	6.8	13.3	1.3	24
Timothy,‡ at different stages:							
Minimum,	47.0	1.4	1.3	5.1	10.1	0.6	.....
Maximum,	78.7	3.2	3.8	19.4	28.6	2.0	.....
Average,	61.6	2.1	3.1	11.8	20.2	1.2	56
Kentucky blue grass,§ at different stages:							
Minimum,	51.7	1.6	2.4	3.8	6.5	0.8	.....
Maximum,	82.5	4.8	7.2	14.8	26.6	1.9	.....
Average,	65.1	2.8	4.1	9.1	17.6	1.3	18
Hungarian grass:							
Minimum,	62.7	1.9	2.8	7.6	9.1	0.5	.....
Maximum,	78.3	2.2	3.2	10.8	20.1	1.1	.....
Average,	71.1	1.7	3.1	9.2	14.2	0.7	14

*Herd's grass of Pennsylvania.

†Meadow oat grass.

‡Herd's grass of New England and New York.

§June grass.

Composition of Feeding Stuffs.—Continued.

	Water.	Ash.	Protein.	Fiber.	Nitrogen-free extract.	Fat.	Number of analyses.
GREEN FODDER—Continued.							
Red clover, at different stages:	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	
Minimum,	47.1	0.9	1.7	1.8	3.5	0.3	.....
Maximum,	91.8	4.0	7.1	14.7	25.8	1.8	.....
Average,	70.8	2.1	4.4	8.1	13.5	1.1	43
Alsike clover,* in bloom:							
Minimum,	72.3	1.9	3.6	5.3	10.8	0.6	.....
Maximum,	77.3	2.1	4.2	9.4	11.5	1.2	.....
Average,	74.8	2.0	3.9	7.4	11.0	0.9	4
Crimson clover:							
Minimum,	78.4	1.4	2.7	3.5	7.0	0.6	.....
Maximum,	84.6	2.0	3.5	6.3	9.7	0.8	.....
Average,	80.9	1.7	3.1	5.2	8.4	0.7	3
Alfalfa,† at different stages:							
Minimum,	49.3	1.8	3.5	2.5	10.8	0.6	.....
Maximum,	82.0	5.1	7.7	14.8	11.5	1.2	.....
Average,	71.8	2.7	4.8	7.4	12.3	1.0	23
Serradella, at different stages:							
Minimum,	65.6	1.8	2.1	2.0	3.9	0.4	.....
Maximum,	84.6	5.8	3.6	7.8	17.1	1.8	.....
Average,	79.5	3.2	2.7	5.4	8.6	0.7	9
Cowpea:							
Minimum,	72.8	1.2	1.5	1.7	1.8	0.2	.....
Maximum,	93.1	2.7	3.5	15.3	12.9	0.6	.....
Average,	83.6	1.7	2.4	4.8	7.1	0.4	10
Soja bean:							
Minimum,	63.6	1.8	2.2	4.8	5.8	0.5	.....
Maximum,	81.5	5.1	5.9	9.7	16.0	1.6	.....
Average,	75.1	2.6	4.0	6.7	10.6	1.0	27
Horse bean:							
Average,	84.2	1.2	2.8	4.9	6.5	0.4	2
Flat pea (<i>Lathyrus sylvestris</i>):							
Average,	66.7	2.9	8.7	7.9	12.2	1.6	2
Rape:							
Average,	84.5	2.0	2.3	2.6	8.4	0.5	2
SILAGE.							
Corn silage:							
Minimum,	62.4	0.3	0.7	3.0	5.1	0.2	.....
Maximum,	87.7	3.3	3.6	10.5	24.2	2.0	.....
Average,	79.1	1.4	1.7	6.0	11.0	0.8	99
Sorghum silage:							
Minimum,	71.9	0.8	0.6	5.9	13.8	0.1	.....
Maximum,	78.0	1.2	0.9	6.8	19.0	0.5	.....
Average,	76.1	1.1	0.8	6.4	15.3	0.3	6
Red clover silage:							
Minimum,	61.4	1.9	3.0	5.1	8.1	0.9	.....
Maximum,	78.6	3.0	5.9	13.9	14.3	1.6	.....
Average,	72.0	2.6	4.2	8.4	11.6	1.2	.....
Soja bean silage:							
Average,	74.2	2.8	4.1	9.7	6.9	2.2	1
Cowpea vine silage:							
Average,	79.3	2.9	2.7	6.0	7.6	1.5	2
Average,	79.3	2.9	2.7	6.0	7.6	1.5	2
Field pea vine silage:							
Average,	50.1	3.5	5.9	13.0	26.0	1.6	1
Silage of mixture of cowpea vines and soja bean vines, average,	69.8	4.5	3.8	9.5	11.1	1.3	1

*Swedish clover.

†Lucern.

Composition of Feeding Stuffs.—Continued.

	Water.	Ash.	Protein.	Fiber.	Nitrogen-free extract.	Fat.	Number of analyses.
HAY AND DRY COARSE FODDER.							
Corn fodder,* field cured:	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	
Minimum,	22.9	1.5	2.7	7.5	20.6	0.6	.....
Maximum,	60.2	5.5	6.9	24.7	47.8	2.5	.....
Average,	42.2	2.7	4.5	14.3	34.7	1.6	35
Corn leaves, field cured:							
Minimum,	14.8	4.3	4.5	17.4	27.3	0.8	.....
Maximum,	44.0	7.4	8.3	27.4	41.4	2.2	.....
Average,	30.0	5.5	6.0	21.4	35.7	1.4	17
Corn husks, field cured:							
Minimum,	26.7	0.6	1.3	6.8	14.3	0.5	.....
Maximum,	76.6	2.3	3.2	23.6	43.6	1.0	.....
Average,	50.9	1.8	2.5	15.8	28.3	0.7	16
Corn stalks, field cured:							
Minimum,	51.3	0.6	1.2	6.9	11.2	0.3	.....
Maximum,	78.5	2.0	3.0	16.8	26.0	1.0	.....
Average,	68.4	1.2	1.9	11.0	17.0	0.5	15
Corn stover,† field cured:							
Minimum,	15.4	1.7	1.9	14.1	23.3	0.7	.....
Maximum,	57.4	7.0	8.3	32.2	53.3	2.2	.....
Average,	40.5	3.4	3.8	19.7	31.5	1.1	60
Hay from:							
Redtop,‡ cut at different stages—							
Minimum,	6.8	3.8	5.9	24.0	44.8	1.4	.....
Maximum,	11.6	7.0	10.4	31.8	50.4	3.2	.....
Average,	8.9	5.2	7.9	28.6	47.5	1.9	9
Redtop, cut in bloom—							
Minimum,	6.8	4.3	7.8	24.0	46.8	1.5	.....
Maximum,	11.6	6.5	10.4	31.8	47.8	2.3	.....
Average,	8.7	4.9	8.0	29.9	46.4	2.1	3
Orchard grass—							
Minimum,	6.5	5.0	6.6	28.9	32.9	1.7	.....
Maximum,	13.6	7.9	10.4	38.3	48.6	3.3	.....
Average,	9.9	6.0	8.1	32.4	41.0	2.6	10
Timothy,§ all analyses—							
Minimum,	6.1	2.5	3.8	22.3	34.3	1.0	.....
Maximum,	28.9	6.3	9.8	38.5	58.5	4.0	.....
Average,	13.2	4.4	5.9	29.0	45.0	2.5	68
Timothy, cut in full bloom—							
Minimum,	7.0	2.5	5.0	22.2	34.4	2.0	.....
Maximum,	28.9	6.0	7.5	37.1	48.5	4.0	.....
Average,	15.0	4.5	6.0	29.6	41.9	3.0	12
Hay from:							
Timothy cut soon after bloom—							
Minimum,	7.8	3.5	4.6	25.7	37.0	1.7	.....
Maximum,	21.6	5.4	8.1	33.4	51.0	3.6	.....
Average,	14.2	4.4	5.7	28.1	44.6	3.0	11
Timothy cut when nearly ripe—							
Minimum,	7.0	2.7	4.3	24.8	38.0	1.0	.....
Maximum,	22.7	5.1	6.0	38.5	49.1	2.8	.....
Average,	14.1	3.9	5.0	31.1	43.7	2.2	12
Minimum,	14.3	4.5	5.3	17.7	31.8	2.0	.....
Maximum,	32.8	7.8	12.9	26.8	51.1	4.2	.....
Average,	21.2	6.3	7.8	23.0	37.8	3.9	10

*Entire plant.

†What is left after the ears are harvested.

‡Herd's grass of Pennsylvania.

§Herd's grass of New England and New York.

Composition of Feeding Stuffs.—Continued.

	Water.	Ash.	Protein.	Fiber.	Nitrogen-free extract.	Fat.	Number of analyses.
HAY AND DRY COARSE FODDER—Continued.							
Cut when seed was in milk—	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	
Minimum,	22.5	5.6	6.0	23.9	33.2	3.4	
Maximum,	26.5	7.6	6.6	24.9	35.4	4.1	
Average,	24.4	7.0	6.3	24.5	34.2	3.6	4
Cut when seed was ripe—							
Minimum,	23.7	5.1	5.3	20.4	33.6	2.8	
Maximum,	32.8	7.3	6.0	25.7	33.7	3.2	
Average,	27.8	6.4	5.8	23.8	33.2	3.0	4
Hungarian grass—							
Minimum,	4.9	5.0	4.7	22.6	44.4	1.5	
Maximum,	9.5	7.5	12.3	36.3	53.0	3.5	
Average,	7.7	6.0	7.5	27.7	49.0	2.1	13
Meadow fescue—							
Minimum,	7.4	5.5	4.5	20.8	22.5	1.6	
Maximum,	22.5	7.3	11.3	31.9	45.5	2.5	
Average,	20.0	6.3	7.0	25.9	33.4	2.7	9
Italian rye grass—							
Minimum,	7.4	6.1	5.7	23.4	39.6	1.3	
Maximum,	9.3	7.9	8.8	33.9	48.9	1.9	
Average,	8.5	6.9	7.5	30.5	45.0	1.7	4
Mixed grasses—							
Minimum,	6.5	2.1	4.3	21.0	33.4	1.3	
Maximum,	33.4	6.9	12.1	38.4	50.8	4.9	
Average,	15.3	5.5	7.4	27.2	41.1	2.5	126
Hay from:							
Rowen (mixed)*							
Minimum,	8.2	5.1	9.6	20.1	33.6	2.2	
Maximum,	24.4	7.3	14.3	20.0	44.3	4.5	
Average,	16.6	6.3	11.6	22.5	39.4	3.1	23
Mixed grasses and clovers—							
Minimum,	8.2	3.9	5.5	19.7	31.8	1.5	
Maximum,	15.9	9.6	14.4	25.1	48.9	3.1	
Average,	12.9	5.5	10.1	27.6	41.3	2.6	17
Swamp hay—							
Minimum,	7.8	3.3	5.0	19.4	39.9	0.8	
Maximum,	17.9	12.1	8.8	31.6	51.7	3.6	
Average,	11.6	6.7	7.2	26.6	45.9	2.0	8
Salt marsh—							
Minimum,	7.3	5.4	4.0	25.1	34.1	1.6	
Maximum,	18.6	11.8	7.3	33.3	54.3	3.1	
Average,	10.4	7.7	5.5	30.0	44.1	2.4	10
Red clover—							
Minimum,	6.0	3.9	10.0	15.6	27.3	1.5	
Maximum,	31.3	8.3	20.2	35.7	52.2	5.9	
Average,	15.3	6.2	12.3	24.8	33.1	3.3	33
Red clover in bloom—							
Minimum,	6.0	5.6	10.8	17.9	27.3	2.5	
Maximum,	31.3	8.3	15.4	28.1	41.3	5.9	
Average,	20.8	6.6	12.4	21.9	33.8	4.5	6
Alsike clover—							
Minimum,	5.3	6.1	9.2	19.7	35.6	1.6	
Maximum,	13.9	12.3	16.1	29.5	46.9	4.2	
Average,	9.7	8.3	12.8	25.6	40.7	2.9	9
White clover—							
Minimum,	6.1	4.5	13.9	20.3	33.4	1.7	
Maximum,	13.5	13.8	20.0	30.3	47.3	5.8	
Average,	9.7	8.3	15.7	24.1	39.3	2.9	7

*Second cut.

Composition of Feeding Stuffs.—Continued.

	Water.	Ash.	Protein.	Fiber.	Nitrogen-free extract.	Fat.	Number of analyses.
HAY AND DRY COARSE FODDER—Continued.							
	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	
Crimson clover—							
Minimum,	5.9	7.4	13.6	20.1	29.3	1.5	.....
Maximum,	13.4	13.0	16.1	24.9	42.6	4.8	.....
Average,	9.6	8.6	15.2	27.2	36.6	2.8	7
Japan clover—							
Average,	11.0	8.5	13.8	24.0	39.0	3.7	2
Vetch—							
Minimum,	8.3	7.1	13.1	19.7	26.5	1.6	.....
Maximum,	15.8	11.6	23.1	28.1	40.2	3.0	.....
Average,	11.3	7.9	17.0	26.4	36.1	2.3	5
Serradella—							
Minimum,	7.2	5.4	13.9	19.4	40.5	2.2	.....
Maximum,	11.7	10.3	16.6	23.9	46.0	2.9	.....
Average,	9.2	7.2	15.2	21.6	44.2	2.6	2
Alfalfa*—							
Minimum,	4.6	3.1	10.2	14.0	35.1	1.1	.....
Maximum,	16.0	10.4	20.3	33.0	53.6	3.8	.....
Average,	8.4	7.4	14.3	25.0	42.7	2.2	21
Cowpea—							
Minimum,	7.6	3.2	13.6	16.4	39.4	1.1	.....
Maximum,	14.0	10.2	20.3	25.0	49.5	3.7	.....
Average,	10.7	7.5	16.6	20.1	42.2	2.2	8
Soja bean—							
Minimum,	6.1	4.8	14.0	17.3	31.8	2.4	.....
Maximum,	20.1	8.9	18.1	32.3	41.0	7.5	.....
Average,	11.3	7.2	15.4	22.3	38.6	5.2	6
Flat pea (<i>Lathyrus sylvestris</i>)—							
Minimum,	6.3	6.5	17.6	18.5	27.7	1.6	.....
Maximum,	10.0	8.6	27.9	32.7	34.0	4.6	.....
Average,	8.4	7.9	22.9	26.2	31.4	3.2	5
Peanut vines (without nuts)—							
Minimum,	6.3	7.3	9.1	18.3	33.1	1.7	.....
Maximum,	7.8	15.7	11.7	33.3	50.4	5.8	.....
Average,	7.6	10.8	10.7	23.6	42.7	4.6	6
Soja bean straw:							
Minimum,	5.7	3.9	4.0	34.0	35.3	0.8	.....
Maximum,	14.0	4.9	4.9	49.6	43.3	3.2	.....
Average,	10.1	5.8	4.6	40.4	37.4	1.7	4
Horse-bean straw:							
Average,	9.2	8.7	8.8	37.6	34.3	1.4	1
Wheat straw:							
Minimum,	6.5	3.0	2.9	34.3	31.0	0.8	.....
Maximum,	17.9	7.0	5.0	42.7	50.6	1.8	.....
Average,	9.6	4.2	3.4	38.1	43.4	1.3	7
Rye straw:							
Minimum,	6.3	2.8	2.2	32.7	41.0	1.0	.....
Maximum,	9.7	3.4	3.6	43.3	52.9	1.6	.....
Average,	7.1	3.2	3.0	38.9	46.6	1.2	7
Oat straw:							
Minimum,	6.5	3.7	2.7	31.8	33.5	1.7	.....
Maximum,	11.4	6.7	6.9	45.1	46.6	3.2	.....
Average,	9.2	5.1	4.0	37.0	42.4	2.3	12
Buckwheat straw:							
Minimum,	9.0	4.9	3.3	37.2	32.1	0.7	.....
Maximum,	10.4	6.5	7.8	46.8	38.9	1.7	.....
Average,	9.9	5.5	5.2	43.0	35.1	1.3	3

*Lucern.

Composition of Feeding Stuffs.—Continued.

	Water.	Ash.	Protein.	Fiber.	Nitrogen-free extract.	Fat.	Number of analyses.
ROOTS AND TUBERS.							
Potatoes:	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	
Minimum,	75.4	0.8	1.1	0.3	14.1	.....
Maximum,	82.2	1.2	3.0	0.9	20.4	0.1	
Average,	78.9	1.0	2.1	0.6	17.3	0.1	12
Sweet potatoes:							
Minimum,	66.0	0.7	0.5	0.6	18.0	0.3	
Maximum,	74.4	1.3	3.6	2.5	29.7	0.6	
Average,	71.1	1.0	1.5	1.3	24.7	0.4	6
Red beets:							
Minimum,	85.8	0.7	1.1	0.6	3.8	0.1	
Maximum,	92.2	1.6	1.8	1.7	11.3	0.3	
Average,	88.5	1.0	1.5	0.9	8.0	0.1	9
Sugar beets:							
Minimum,	85.0	0.4	1.1	0.6	5.7	0.1	
Maximum,	90.8	1.2	3.2	1.3	13.6	0.2	
Average,	86.5	0.9	1.8	0.9	9.8	0.1	19
Mangel-wurzels:							
Minimum,	86.9	0.8	1.0	0.6	2.4	0.1	
Maximum,	94.4	1.4	1.9	1.3	8.7	0.5	
Average,	90.9	1.1	1.4	0.9	6.5	0.2	9
Turnips:							
Minimum,	87.2	0.7	0.8	0.8	4.2	0.1	
Maximum,	92.4	1.0	1.4	1.4	8.8	0.2	
Average,	90.5	0.8	1.1	1.2	6.2	0.2	3
Rutabagas							
Minimum,	87.1	1.0	1.0	1.1	5.1	0.1	
Maximum,	91.8	1.4	1.3	1.4	9.1	0.3	
Average,	88.6	1.2	1.2	1.3	7.5	0.2	4
Carrots:							
Minimum,	86.5	1.6	0.8	0.9	5.1	0.2	
Maximum,	91.1	1.3	2.0	2.3	10.4	0.7	
Average,	88.6	1.0	1.1	1.3	7.6	0.4	8
Artichokes:							
Average,	79.5	1.0	2.6	0.8	15.9	0.2	2
GRAINS AND OTHER SEEDS.							
Corn kernels:							
Dent, all analyses—							
Minimum,	6.2	1.0	7.5	0.9	65.9	3.1	
Maximum,	19.4	2.6	11.8	4.8	75.7	7.5	
Average,	10.6	1.5	10.3	2.2	70.4	5.0	86
Flint, all analyses—							
Minimum,	4.5	1.0	7.0	0.7	65.0	3.4	
Maximum,	19.6	1.9	13.7	2.9	76.7	7.1	
Average,	11.3	1.4	10.5	1.7	70.1	5.0	68
Sweet, all analyses—							
Minimum,	6.0	1.4	9.5	1.5	61.8	3.8	
Maximum,	10.9	2.4	15.3	5.2	72.4	9.3	
Average,	8.8	1.9	11.6	2.8	66.8	8.1	25
Pop varieties—							
Minimum,	8.6	1.2	9.7	1.2	68.4	4.2	
Maximum,	11.8	1.7	13.1	2.3	71.1	6.0	
Average,	10.7	1.5	11.2	1.8	69.6	5.2	4
Soft varieties—							
Minimum,	6.1	1.4	8.8	1.3	66.0	5.0	
Maximum,	14.1	1.9	14.6	3.3	75.5	5.7	
Average,	9.3	1.6	11.4	2.0	70.2	5.5	5
All varieties and analyses—							
Minimum,	4.5	1.0	7.0	0.7	61.8	3.1	
Maximum,	20.7	2.6	15.3	5.2	76.7	9.3	
Average,	10.9	1.5	10.5	2.1	69.6	5.4	208

Composition of Feeding Stuffs.—Continued.

	Water.	Ash.	Protein.	Fiber.	Nitrogen-free extract.	Fat.	Number of analyses.
GRAINS AND OTHER SEEDS—Continued.							
Sorghum seed:	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	
Minimum,	9.3	1.4	7.7	1.5	59.0	2.1	.....
Maximum,	16.8	4.3	11.3	8.7	73.6	4.6	.....
Average,	12.8	2.1	9.1	2.6	69.8	2.6	10
Barley:							
Minimum,	7.2	1.8	8.6	1.3	66.7	1.5	.....
Maximum,	12.6	3.2	15.7	4.2	73.9	3.2	.....
Average,	10.9	2.4	12.4	2.7	69.8	1.8	10
Oats:							
Minimum,	8.9	2.0	8.0	1.5	53.5	3.4	.....
Maximum,	13.5	4.0	14.4	12.9	66.9	5.8	.....
Average,	11.0	3.0	11.8	9.5	59.7	5.0	30
Rye:							
Minimum,	8.7	1.8	9.5	1.4	71.2	1.4	.....
Maximum,	13.2	1.9	12.1	2.1	73.9	2.1	.....
Average,	11.6	1.9	10.6	1.7	72.5	1.7	6
Wheat, spring varieties:							
Minimum,	8.1	1.5	8.4	1.3	66.1	1.8	.....
Maximum,	13.4	2.6	15.4	2.3	74.9	2.6	.....
Average,	10.4	1.9	12.5	1.8	71.2	2.2	18
Wheat, winter varieties, all analyses:							
Minimum,	7.1	0.8	8.1	0.4	66.7	1.3	.....
Maximum,	14.0	3.6	16.6	2.9	77.7	3.9	.....
Average,	10.5	1.3	11.8	1.8	72.0	2.1	262
Wheat, all varieties:							
Minimum,	7.1	0.8	8.1	0.4	64.8	1.3	.....
Maximum,	14.0	3.6	17.2	3.1	77.7	3.9	.....
Average,	10.5	1.8	11.9	1.8	71.9	2.1	310
Rice:							
Minimum,	11.4	0.3	5.9	0.1	77.5	0.3	.....
Maximum,	14.0	0.5	8.6	0.4	80.6	0.6	.....
Average,	12.4	0.4	7.4	0.2	79.2	0.4	10
Buckwheat:							
Minimum,	10.9	1.6	8.6	7.8	62.6	2.2	.....
Maximum,	14.8	2.3	11.0	9.4	65.4	2.4	.....
Average,	12.6	2.0	10.0	8.7	64.5	2.2	8
Sunflower seed (whole):							
Minimum,	8.5	2.1	15.8	29.5	22.0	20.9	.....
Maximum,	8.8	3.3	16.7	30.3	20.7	21.5	.....
Average,	8.6	2.6	16.3	29.9	21.4	21.2	2
Cotton seed, whole (with hulls):							
Minimum,	7.0	2.9	14.5	20.3	17.3	18.9	.....
Maximum,	17.5	4.5	21.7	28.7	29.1	21.6	.....
Average,	10.3	3.5	18.4	23.2	24.7	19.9	5
Cotton seed kernels (without hulls):							
Minimum,	6.0	4.0	29.3	3.1	15.8	36.5	.....
Maximum,	6.3	5.4	33.1	4.4	19.5	36.6	.....
Average,	6.2	4.7	31.2	3.7	17.6	36.6	2
Cotton seed, whole, (roasted):							
Minimum,	2.9	2.8	16.1	16.8	21.1	22.5	.....
Maximum,	9.3	8.7	17.6	24.0	25.8	32.7	.....
Average,	6.1	5.5	16.8	20.4	23.5	27.7	2
Peanut kernel (without hulls):							
Minimum,	4.9	1.9	23.2	2.0	12.7	35.0	.....
Maximum,	13.2	3.8	31.4	18.4	19.1	47.4	.....
Average,	7.5	2.4	27.9	7.0	15.6	39.6	7
Horse bean,	11.3	3.8	26.6	7.2	50.1	1.0	1
Soja bean:							
Minimum,	5.9	3.1	26.3	3.4	26.2	12.3	.....
Maximum,	19.8	5.4	40.2	6.1	32.8	19.0	.....
Average,	10.8	4.7	34.0	4.8	28.8	16.9	8

Composition of Feeding Stuffs.—Continued.

	Water.	Ash.	Protein.	Fiber.	Nitrogen-free extract.	Fat.	Number of analyses.
GRAINS AND OTHER SEEDS—Continued.							
Cowpea:	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	
Minimum,	10.0	2.9	19.3	2.5	50.5	1.3	.....
Maximum,	20.9	3.4	23.0	5.0	62.0	1.6	.....
Average,	14.8	3.2	20.8	4.1	55.7	1.4	5
MILL PRODUCTS.							
Corn meal:							
Minimum,	8.0	0.9	7.1	0.5	60.4	2.0	.....
Maximum,	27.4	4.1	13.9	3.1	74.0	5.1	.....
Average,	15.0	1.4	9.2	1.9	63.7	3.8	77
Corn and cob meal:							
Minimum,	9.5	1.2	5.8	4.7	56.8	2.5	.....
Maximum,	26.3	1.9	12.2	9.4	60.7	4.7	.....
Average,	15.1	1.5	8.5	6.6	64.8	3.5	7
Oat meal:							
Minimum,	6.2	1.8	12.9	0.6	66.6	6.1	.....
Maximum,	8.8	2.2	16.3	1.2	69.0	8.8	.....
Average,	7.9	8.0	14.7	0.9	67.4	7.1	6
Barley meal:							
Minimum,	9.9	1.6	9.8	5.9	63.5	1.5	.....
Maximum,	13.6	3.8	12.7	7.0	68.0	3.2	.....
Average,	11.9	2.6	10.5	6.5	66.3	2.2	3
Rye flour:							
Minimum,	12.4	0.6	0.4	6.0	77.6	0.8	.....
Maximum,	13.6	0.8	6.9	0.5	79.1	0.9	.....
Average,	13.1	0.7	6.7	0.4	78.3	0.8	4
Wheat flour, all analyses:							
Minimum,	8.2	0.3	8.6	0.1	71.5	0.6	.....
Maximum,	13.6	0.7	13.6	1.0	78.5	1.8	.....
Average,	12.4	0.5	10.8	0.2	75.0	1.1	20
Buckwheat flour:							
Minimum,	12.8	0.7	4.2	0.2	71.1	0.7	.....
Maximum,	17.6	1.3	8.1	0.5	79.4	1.8	.....
Average,	14.6	1.0	6.9	0.3	75.8	1.4	4
Ground linseed:							
Minimum,	7.9	3.4	20.3	5.0	25.5	30.3	.....
Maximum,	8.3	6.1	23.0	9.6	30.2	30.5	.....
Average,	8.1	4.7	21.6	7.3	27.9	30.4	2
Pea meal:							
Minimum,	8.9	2.6	19.1	17.1	50.2	0.9	.....
Maximum,	12.1	2.7	21.4	17.7	52.0	1.5	.....
Average,	10.5	2.6	20.2	14.4	51.1	1.2	2
Soja-bean meal,	10.8	455	36.7	4.5	27.3	16.2	1
Ground corn and oats, equal parts:							
Minimum,	10.7	1.9	8.4	.....	*70.4	4.0	.....
Maximum,	13.1	2.7	10.4	.....	*78.7	5.0	.....
Average,	11.9	2.2	9.6	.....	*72.0	4.4	6
WASTE PRODUCTS.							
Corn-cob:							
Minimum,	7.2	0.7	1.2	18.2	43.8	0.1	.....
Maximum,	24.8	2.7	3.7	38.3	66.7	0.9	.....
Average,	10.7	1.4	2.4	30.1	54.9	0.5	13
Hominy chops:							
Minimum,	8.1	1.9	7.9	2.5	61.0	4.5	.....
Maximum,	13.5	3.1	11.2	6.7	71.1	11.2	.....
Average,	11.1	2.5	9.8	3.8	64.5	8.3	12
Corn-germ:							
Minimum,	9.4	1.9	9.7	1.9	61.9	5.2	.....
Maximum,	13.0	7.4	9.9	5.8	67.4	11.2	.....
Average,	10.7	4.0	9.8	4.1	64.0	7.4	3

*Including fiber.

Composition of Feeding Stuffs.—Continued.

	Water.	Ash.	Protein.	Fiber.	Nitrogen-free extract.	Fat.	Number of analyses.
WASTE PRODUCTS—Continued.							
Corn-germ meal:	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	
Minimum,	6.5	0.8	10.0	7.8	57.4	4.3	.....
Maximum,	9.9	2.6	14.0	13.0	67.0	11.2	.....
Average,	8.1	1.3	11.1	9.9	62.5	7.1	6
Gluten meal:							
Minimum,	6.2	0.5	21.3	0.3	34.0	3.4	.....
Maximum,	12.3	2.0	39.2	7.8	58.5	20.0	.....
Average,	8.8	0.8	29.7	2.2	49.8	8.7	54
Recent analyses—							
Minimum,	6.2	0.5	21.4	0.6	34.0	6.6	.....
Maximum,	11.1	2.0	39.3	7.8	58.4	20.0	.....
Average,	8.2	0.9	29.3	3.3	46.5	11.8	20
Chicagot—							
Average,	10.1	1.1	30.1	1.6	48.7	8.4	6
Buffalot—							
Average,	8.2	0.8	23.3	6.1	50.4	11.3	5
Cream gluten:							
Minimum,	7.7	0.6	34.1	1.2	35.0	13.6	.....
Maximum,	9.0	0.8	38.2	1.3	41.1	15.3	.....
Average,	8.1	0.7	36.1	1.3	39.0	14.8	3
Gluten feed:							
Minimum,	6.3	0.7	19.5	1.5	44.5	7.0	.....
Maximum,	9.0	1.8	28.3	8.2	58.0	12.6	.....
Average,	7.8	1.1	24.0	5.3	51.2	10.6	11
Buffalot—							
Average,	7.7	1.1	25.0	5.3	49.3	11.6	5
Pope's,	14.0	0.6	33.3	1.6	36.5	14.1	1
Peoria,†	7.5	0.8	19.8	8.2	51.1	12.6	1
Chicago maize feed:							
Minimum,	8.6	0.7	19.3	6.8	49.2	5.6	.....
Maximum,	9.7	1.1	26.9	8.7	56.1	7.9	.....
Average,	9.1	0.9	22.8	7.6	52.7	6.9	3
Glucose feed and glucose refuse:							
Average,	6.5	1.1	20.7	4.5	56.8	10.4	2
Dried starch feed and sugar feed:							
Minimum,	9.2	0.6	17.1	3.1	49.2	7.3	.....
Maximum,	11.7	1.2	22.1	5.6	59.6	11.1	.....
Average,	10.9	0.9	19.7	4.7	54.8	9.0	4
Starch feed, wet:							
Minimum,	62.3	0.1	3.6	1.6	18.7	1.3	.....
Maximum,	72.2	0.6	9.6	4.4	23.9	4.4	.....
Average,	65.4	0.3	6.1	3.1	22.0	3.1	13
Oat feed:							
Minimum,	6.4	3.2	12.6	3.7	56.2	6.1	.....
Maximum,	9.2	4.2	20.0	12.5	63.7	7.8	.....
Average,	7.7	3.7	16.0	6.1	59.4	7.1	4
Barley screenings:							
Minimum,	12.0	3.5	12.1	7.0	61.6	2.6	.....
Maximum,	12.4	3.6	12.5	7.6	62.0	2.9	.....
Average,	12.2	3.6	12.3	7.3	61.8	2.8	2
Malt sprouts:							
Minimum,	7.3	3.8	21.0	9.3	45.5	1.0	.....
Maximum,	12.0	6.7	25.9	12.0	50.3	3.0	.....
Average,	10.2	5.7	23.2	10.7	48.5	1.7	4
Brewers' grains, wet:							
Minimum,	68.6	0.3	4.3	3.1	9.6	0.8	.....
Maximum,	79.4	1.5	6.9	5.6	15.9	2.8	.....
Average,	75.7	1.0	5.4	3.8	12.5	1.6	15

†Included in above average.

Composition of Feeding Stuffs.—Continued.

	Water.	Ash.	Protein.	Fiber.	Nitrogen-free extract.	Fat.	Number of analyses.
WASTE PRODUCTS—Continued.							
Brewers' grains, dried:	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	
Minimum,	6.2	3.3	19.3	10.2	46.1	4.2	.....
Maximum,	11.9	3.8	20.3	11.6	56.8	6.5	.....
Average,	8.2	3.6	19.9	11.0	51.7	5.6	3
Grano gluten,	5.8	2.8	31.1	12.0	33.4	14.9	1
Rye bran:							
Minimum,	8.2	2.9	11.5	2.5	59.3	1.7	.....
Maximum,	13.7	4.5	16.8	4.1	67.6	4.9	.....
Average,	11.6	3.6	14.7	3.5	63.8	2.8	7
Wheat bran from spring wheat:							
Minimum,	7.4	4.0	14.3	5.4	51.7	3.6	.....
Maximum,	13.6	6.0	18.1	10.1	58.1	5.0	.....
Average,	11.5	5.4	16.1	8.0	54.5	4.5	10
Wheat bran from winter wheat:							
Minimum,	10.6	5.0	13.9	7.2	50.5	3.5	.....
Maximum,	13.6	6.4	17.8	8.9	56.2	4.5	.....
Average,	12.3	5.9	16.0	8.1	53.7	4.0	7
Wheat bran, all analyses:							
Minimum,	7.4	2.5	12.1	2.4	45.5	1.5	.....
Maximum,	15.8	7.8	18.9	15.5	63.2	7.0	.....
Average,	11.9	5.8	15.4	9.0	53.9	4.0	88
Wheat middlings:							
Minimum,	9.2	1.4	10.1	1.3	53.0	2.1	.....
Maximum,	16.0	6.3	20.0	12.7	70.9	5.9	.....
Average,	12.1	3.3	15.6	4.6	60.4	4.0	32
Wheat shorts:							
Minimum,	4.1	2.0	11.1	6.0	50.0	2.5	.....
Maximum,	15.5	6.2	19.4	10.5	67.0	6.1	.....
Average,	11.8	4.6	14.9	7.4	56.8	4.5	12
Wheat screenings:							
Minimum,	7.8	1.9	8.3	1.7	61.0	2.7	.....
Maximum,	13.6	3.3	16.9	7.5	70.4	3.3	.....
Average,	11.6	2.9	12.5	4.9	65.1	3.0	10
Rice bran:							
Minimum,	8.8	8.4	10.9	2.0	41.9	5.2	.....
Average,	9.7	10.0	12.1	9.5	49.9	8.8	5
Maximum,	10.7	12.4	13.6	17.8	62.3	10.9	.....
Rice hulls:							
Minimum,	7.7	10.5	2.9	30.3	36.0	0.6	.....
Maximum,	8.5	15.1	4.7	38.6	41.6	0.9	.....
Average,	8.2	13.2	3.6	35.7	38.6	0.7	3
Rice polish:							
Minimum,	9.0	2.8	10.9	2.4	45.5	6.5	.....
Maximum,	11.2	11.3	12.9	14.5	63.3	8.0	.....
Average,	10.0	6.7	11.7	6.3	58.0	7.3	4
Buckwheat middlings:							
Minimum,	9.5	4.4	25.1	2.4	36.3	5.7	.....
Maximum,	16.3	5.5	31.3	5.7	52.7	8.1	.....
Average,	13.2	4.8	28.9	4.1	41.9	7.1	.....
Cotton seed meal:							
Minimum,	5.8	5.7	23.3	1.3	15.7	8.8	.....
Maximum,	18.5	8.8	50.8	10.1	38.7	13.0	.....
Average,	8.2	7.2	42.3	5.6	23.6	13.1	35
Cotton seed hulls:							
Minimum,	9.2	1.8	2.2	37.9	12.4	0.6	.....
Maximum,	16.7	4.4	5.4	67.0	41.8	5.4	.....
Average,	11.1	2.8	4.2	46.3	33.4	2.2	20
Linseed meal, old process:							
Minimum,	5.6	4.6	27.7	4.7	23.4	5.2	.....
Maximum,	12.4	8.2	38.2	12.9	41.9	11.6	.....
Average,	9.2	5.7	32.9	8.9	35.4	7.9	21

Composition of Feeding Stuffs.—Continued.

	Water.	Ash.	Protein.	Fiber.	Nitrogen-free extract.	Fat	Number of analyses.
WASTE PRODUCTS—Continued.							
Linsed meal, new process:	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	
Minimum,	6.0	5.0	27.1	7.6	35.2	1.3	.....
Maximum,	13.4	6.9	38.4	4.0	48.0	4.4	.....
Average,	10.1	5.8	33.2	9.5	38.4	3.0	14
Peanut meal:*							
Minimum,	6.6	3.7	37.5	2.5	28.5	5.8	.....
Maximum,	15.4	5.5	52.4	7.4	30.8	17.5	.....
Average,	10.7	4.9	47.6	5.1	23.7	8.0	2,480
Peanut hulls:							
Minimum,	7.8	1.9	4.6	56.5	9.7	0.9	.....
Maximum,	10.8	4.6	8.6	72.3	18.9	2.0	.....
Average,	9.0	3.4	6.6	64.3	15.1	1.6	5
MILK AND ITS BY-PRODUCTS.							
Whole milk:							
Minimum,	80.3	0.4	2.1	.....	2.1	1.7	.....
Maximum,	90.7	1.2	6.4	.....	6.1	6.5	.....
Average,	87.2	0.7	3.6	.....	4.9	3.7	798
Skim milk, cream raised by setting:							
Minimum,	88.3	0.5	2.6	.....	3.8	0.2	.....
Maximum,	92.6	1.0	3.9	.....	5.5	2.5	.....
Average,	90.4	0.7	3.3	.....	4.7	0.9	96
Skim milk, cream raised by separator:							
Minimum,	89.8	.....	.....	.....	.....	.....	.....
Maximum,	91.2	.....	.....	.....	.....	.....	.....
Average,	90.6	0.7	3.1	.....	5.3	0.3	7
Butter milk:							
Minimum,	82.2	0.4	1.7	.....	2.5	.....	.....
Maximum,	93.3	0.9	6.2	.....	5.6	5.4	.....
Average,	90.1	0.7	4.0	.....	4.0	1.1	85
Whey:							
Minimum,	93.2	0.3	0.3	.....	4.4	0.0	.....
Maximum,	94.6	0.6	1.2	.....	5.8	0.2	.....
Average,	93.8	0.4	0.6	.....	5.1	0.1	46

*Mostly European analyses.

FERTILIZING CONSTITUENTS OF AMERICAN FEEDING STUFFS AND MANURIAL VALUE PER TON.

Taken from Bulletin No. 16, Prepared by Enos H. Hess, of the State Experiment Station, Pennsylvania.

In commercial fertilizers there are only three ingredients which are assumed to have any practical value, namely: Nitrogen, phosphoric acid and potash. The foods used in feeding dairy cattle contain more or less of these three ingredients, and therefore, have a fertilizing value equal to the amount of nitrogen, phosphoric acid

and potash they contain. The nitrogen is valued at twelve cents per pound, the phosphoric acid at four cents and potash at five cents per pound. No allowance is made for the value of the humus, which has some value, but as to how much it has, will have to be left to the judgment of the reader, for as yet it has not been scientifically determined.

	Pounds in 100 Pounds.			Manurial Value in Dollars per Ton.			
	Nitrogen.	Phosphoric acid.	Potash.	Nitrogen.	Phosphoric acid.	Potash.	Total.
SOILING FODDER.							
	Lbs.	Lbs.	Lbs.				
Corn—dent, cut before glazing,	0.41	0.14	0.33	\$0.984	\$0.120	\$0.33	\$1.43
Cow pea,	0.27	0.10	0.31	.648	.080	.31	1.01
Crimson clover (just heading),*	0.40	0.12	0.34	.960	.096	.34	1.40
Crimson clover (full bloom),*	0.51	0.12	0.35	1.224	.096	.35	1.67
Orchard grass (in bloom),	0.43	0.16	0.76	1.032	.128	.76	1.92
Pasture grass,*	0.75	0.19	0.60	1.800	.152	.60	2.55
Red clover,	0.53	0.13	0.46	1.272	.104	.46	1.84
Rye,	0.33	0.15	0.73	.792	.120	.73	1.64
Soja bean,	0.29	0.15	0.53	.696	.120	.53	1.35
SILAGE.							
Corn silage—average of all analyses,	0.23	0.11	0.37	.672	.068	.37	1.13
Red clover,	0.53	0.13	0.46	1.272	.104	.46	1.84
HAY, STRAW, ETC.							
Alfalfa hay,	2.19	0.51	1.68	5.256	.408	1.68	7.34
Corn fodder—field cured,	1.76	0.54	0.89	4.225	.432	.89	5.55
Corn stover—field cured,	1.04	0.29	1.40	2.496	.232	1.40	4.13
Clover hay—red,	2.07	0.38	2.20	4.968	.304	2.20	7.47
Hungarian grass hay,	1.20	0.35	1.30	2.880	.280	1.30	4.46
Mixed meadow grass hay,*	1.02	0.26	1.48	2.448	.208	1.48	4.14
Mixed hay,	1.67	0.46	1.55	4.009	.368	1.55	5.93
Oat straw,	0.62	0.20	1.24	1.488	.160	1.24	2.89
Orchard grass hay,	1.31	0.01	1.88	3.144	.328	1.88	5.35
Red top hay,	1.15	0.36	1.02	2.760	.288	1.02	4.07
Rye straw,	0.46	0.23	0.79	1.104	.224	.79	2.12
Timothy hay,	1.26	0.53	0.90	3.024	.424	.90	4.35
Wheat straw,	0.59	0.70	0.42	1.396	.560	.42	2.38
Wheat chaff,	0.79	0.70	0.42	1.896	.560	.42	2.88
ROOTS AND TUBERS.							
Carrots,	0.15	0.09	0.51	.360	.072	.51	.94
Mangel wurzels,	0.19	0.09	0.38	.456	.072	.33	.91
Potatoes,	0.21	0.07	0.29	.504	.056	.29	.85
Rutabagas,	0.19	0.12	0.49	.456	.096	.49	1.04
Sugar beets,	0.22	0.10	0.48	.528	.080	.48	1.00
Turnips,	0.18	0.10	0.39	.432	.080	.39	.90
GRAIN.							
Barley,	1.51	0.79	0.48	3.625	.632	.48	4.74
Buckwheat,	1.44	0.44	0.21	3.456	.352	.21	4.02

*Taken from New Jersey report for 1894.

Fertilizing Constituents of American Feeding Stuffs and Manurial Value Per Ton.—Continued.

	Pounds in 100 Pounds.			Manurial Value in Dollars per Ton.			
	Nitrogen.	Phosphoric acid.	Potash.	Nitrogen.	Phosphoric acid.	Potash.	Total.
GRAIN—Continued.							
	Lbs.	Lbs.	Lbs.				
Corn—dent,*	1.65	0.70	0.40	\$3.961	\$0.560	\$0.40	\$4.92
Corn—flint,*	1.63	0.70	0.40	4.033	.560	.40	4.99
Corn—sweet,*	1.82	0.72	0.41	4.369	.576	.41	5.36
Oats,	2.06	0.82	0.62	4.945	.656	.62	6.22
Peas,	3.08	0.82	0.99	7.393	.656	.99	9.04
Rye,	1.76	0.82	0.54	4.225	.656	.54	5.42
Scorghum seed,	1.48	0.81	0.42	3.553	.643	.42	4.62
Wheat—spring,	2.36	0.70	0.39	5.665	.500	.39	6.62
Wheat—winter,	2.36	0.89	0.61	5.665	.712	.61	6.99
MILL PRODUCTS.							
Barley meal,	1.55	0.66	0.34	3.720	.528	.34	4.59
Buckwheat middlings,	4.62	1.73	1.56	11.068	1.384	1.560	14.032
Corn meal,	1.58	.063	0.40	3.792	.504	.40	4.70
Corn-and-cob meal,	1.41	0.57	0.47	3.384	.456	.47	4.31
Pea meal,	3.08	0.82	0.99	7.392	.656	.99	9.04
Rye bran,	2.32	2.28	1.40	6.568	1.824	1.40	8.79
Wheat bran,	2.67	2.89	1.61	6.408	2.312	1.61	10.33
Wheat middlings,	2.63	0.95	0.63	6.312	.760	.63	7.70
Wheat shorts,*	2.42	1.38	0.65	5.808	1.404	.65	7.56
BY-PRODUCTS AND WASTE MATERIAL.							
Apple pomace,	0.23	0.02	0.13	0.552	0.016	.013	0.70
Brewers' grains—dried,	3.06	1.26	1.55	7.320	1.008	1.55	9.88
Brewers' grains—wet,	0.89	0.31	0.05	2.136	.248	.05	2.43
Cerealine feed,*	1.69	1.25	0.67	4.056	1.000	.67	5.73
Corn oil meal,*	3.96	1.45	0.17	9.504	1.160	.17	10.83
Corn cobs,	0.50	0.06	0.60	1.200	.048	.60	1.85
Cotton seed hulls,	0.75	0.18	1.08	1.800	.144	1.08	3.02
Cotton seed meal,	6.64	2.68	1.79	15.936	2.144	1.79	19.87
Gluten meal,	5.03	9.33	0.05	12.072	.264	.05	12.39
Buffalo gluten feed,*	3.44	0.38	0.07	8.256	.304	.07	8.63
Chicago gluten meal,*	5.52	0.29	0.05	13.284	.232	.05	13.53
Grano gluten feed,*	4.96	0.66	0.20	11.904	.528	.20	12.63
Germ meal,*	3.48	6.16	2.91	8.352	4.928	2.91	16.19
Linseed meal— new process,	5.73	1.83	1.39	13.872	1.464	1.39	16.73
Linseed meal—old process,	5.43	1.66	1.37	13.032	1.328	1.37	15.73
Malt sprouts,	3.55	1.43	1.63	8.250	1.144	1.63	11.29
DAIRY PRODUCTS.							
Butter,	0.12	0.04	0.04	.238	.032	.04	.36
Buttermilk,	0.48	0.17	0.16	1.152	.136	.16	1.45
Cheese,	3.93	0.60	0.12	9.432	.480	.12	10.03
Cream,	0.40	0.15	0.13	.960	.120	.13	1.21
Milk,	0.53	0.19	0.18	1.272	.152	.18	1.60
Skim-milk,	0.56	0.20	0.19	1.344	.160	.19	1.69
Whey,	0.15	0.14	0.18	.360	.112	.18	.66

*Taken from New Jersey report for 1894.

The above table shows a very wide range in the fertilizing value of the different dairy foods and products. The highest value per ton is \$19.87 for cotton seed meal and the lowest is 36 cents for butter. The importance of the fertilizing value of foods is, therefore, clearly seen and must be carefully studied if the maximum results are to be obtained.

TABLE I—Population of Pennsylvania by Counties: 1790 to 1900.

Counties.	1900.	1890.	1880.	1870.	1860.	1850.	1840.	1830.	1820.	1810.	1800.	1790.
The State,	6,302,115	5,238,014	4,282,891	3,521,951	2,906,215	2,311,786	1,794,083	1,348,233	1,047,507	810,081	602,865	434,373
Adams,	34,490	33,486	32,455	30,315	28,006	26,981	23,044	21,379	19,370	15,152	13,172	.....
Allegheny,	771,063	551,959	355,869	282,204	178,831	138,290	81,235	50,532	34,921	25,317	15,067	10,309
Armstrong,	52,551	46,747	47,641	43,382	35,797	29,560	28,385	17,701	10,324	6,143	2,899	.....
Beaver,	56,332	50,077	39,606	36,148	29,140	26,689	29,363	24,133	13,340	12,168	6,776	.....
Bedford,	39,468	38,644	34,929	29,635	26,736	23,063	29,335	24,602	20,248	15,746	12,039	13,124
Berks,	138,615	137,327	122,927	106,701	93,818	77,139	61,569	53,152	46,275	43,146	32,407	30,179
Bial,	35,090	70,969	52,740	38,051	27,829	21,777	.....	.....	.....	.....	.....	.....
Bradford,	59,403	59,232	58,541	53,204	48,734	42,831	32,769	19,746	11,554	.....	.....	.....
Bucks,	71,190	70,615	68,656	64,386	63,578	56,091	48,107	46,745	37,842	32,371	27,496	25,401
Butler,	58,962	55,339	52,536	36,510	35,594	30,346	22,378	14,581	10,193	7,246	3,915	.....
Cambria,	104,837	66,375	46,811	36,569	29,155	17,773	11,256	7,076	3,237	2,117	.....	.....
Cameron,	7,048	7,283	5,139	4,273	.....	.....	.....	.....	.....	.....	.....	.....
Carbon,	44,513	38,624	31,923	26,144	21,033	15,066	.....	.....	.....	.....	.....	.....
Centre,	42,894	43,269	37,922	34,418	27,000	23,355	29,492	18,879	13,796	10,681	13,609	97,552
Chester,	95,635	89,577	83,481	77,805	74,578	66,438	57,515	50,910	44,461	39,596	32,093	27,377
Clarion,	34,283	38,802	40,324	36,537	24,968	23,565	.....	.....	.....	.....	.....	.....
Clearfield,	80,614	69,565	43,408	25,741	18,759	12,686	7,834	4,803	2,342	875	.....	.....
Clinton,	29,137	28,685	26,278	23,211	17,723	11,207	8,323	.....	.....	.....	.....	.....
Columbia,	39,896	36,832	32,409	28,766	25,065	17,710	24,287	20,069	17,621	6,178	2,346	.....
Crawford,	33,643	85,324	98,607	63,882	48,755	37,849	31,724	16,930	9,397	.....	.....	.....
Cumberland,	50,344	47,871	45,977	43,912	40,068	34,327	39,953	29,290	23,606	26,757	25,386	18,243
Dauphin,	114,441	96,977	76,148	60,740	46,756	35,754	30,118	25,243	21,653	31,883	22,270	18,177
Delaware,	94,762	74,683	66,101	39,403	30,597	24,679	19,791	17,323	14,810	14,734	12,809	9,483
Elk,	32,903	22,239	12,800	8,493	5,915	3,531	.....	.....	.....	.....	.....	.....
Essex,	93,473	86,074	74,688	65,973	49,432	38,742	31,344	17,041	8,541	3,758	1,468	.....
Fayette,	110,413	80,006	53,842	43,284	39,909	39,112	33,574	29,172	27,285	24,714	20,159	13,325
Forest,	11,038	8,482	4,355	4,010	898	.....	.....	.....	.....	.....	.....	.....
Franklin,	14,902	51,433	49,855	45,365	42,126	39,904	37,793	36,037	31,392	23,083	19,638	15,666
Fulton,	9,924	10,137	10,149	9,360	9,131	7,567	.....	.....	.....	.....	.....	.....
Greene,	28,281	28,935	28,743	25,887	24,343	22,136	19,147	18,028	15,554	12,544	8,605	.....
Huntingdon,	34,650	35,751	33,954	31,251	28,100	24,786	35,484	27,145	20,139	14,778	13,008	7,565
Indiana,	42,556	49,175	40,527	36,138	33,687	27,170	20,752	14,252	8,882	6,214	.....	.....

TABLE I—Population of Pennsylvania by Counties: 1790 to 1900—Continued.

Counties.	1900.	1890.	1880.	1870.	1860.	1850.	1840.	1830.	1820.	1810.	1800.	1790.
Jefferson,	59,113	44,006	27,935	21,656	18,270	13,618	7,253	2,025	561	161		
Junata,	18,054	16,655	18,227	17,890	16,986	13,029	11,080					
Lackawanna,	193,831	142,068	89,289									
Lancaster,	159,241	149,096	139,447									
Lawrence,	57,043	87,517	33,312	27,896	22,999	21,079	84,203	76,681	67,975	53,977	48,403	36,147
Lebanon,	63,827	48,131	38,476	34,066	31,831	26,071	21,872	20,557	16,975			
Lehigh,	93,893	76,621	65,966	56,796	43,753	32,479	25,787	22,256	18,895			
Luzerne,	257,121	201,203	133,065	169,915	90,244	56,072	44,006	27,379	20,027	13,109	12,939	4,904
Lycoming,	76,663	70,579	57,486	47,696	37,389	26,287	22,649	17,636	13,617	11,006	6,414	
McKean,	51,843	46,863	42,565	8,859	5,254	3,975	2,975	1,439	728	142		
Mercer,	57,357	55,744	56,161	49,977	36,856	33,172	32,873	19,729	11,681	8,377	3,228	
Mifflin,	23,160	19,966	19,577	17,568	16,840	14,860	13,092	21,680	16,618	12,132	*	
Monroe,	21,161	20,111	20,175	18,362	16,768	13,270	9,873					
Montgomery,	138,995	123,290	96,494	81,613	70,500	68,291	47,241	39,406	35,793	29,708	24,150	22,929
Montour,	15,526	15,646	15,468	15,844	13,063	13,239						
Northampton,	99,687	84,220	70,312	61,432	47,904	40,235	40,996	39,482	31,765	38,145	30,062	24,250
Northumberland,	90,911	74,688	53,123	41,444	26,922	23,272	20,027	18,133	15,424	36,327	27,797	17,161
Perry,	26,263	26,276	27,522	25,447	22,793	20,068	17,096	14,261	11,234			
Philadelphia,	1,293,687	1,046,964	847,170	674,022	666,529	408,763	258,037	188,797	136,637	111,210	81,009	54,391
Pike,	8,766	9,412	9,633	8,436	7,155	5,881	3,832	4,943	2,890			
Potter,	50,621	23,778	13,797	11,265	11,470	6,048	3,371	1,265	136	29		
Schuylkill,	172,927	154,163	129,974	116,428	89,510	60,713	29,063	20,744	11,311			
Snyder,	17,304	17,651	17,797	15,606	15,035							
Somerset,	49,461	37,317	33,110	26,226	26,778	24,416	19,650	17,762	13,974	11,264	10,188	
Sullivan,	13,134	11,620	8,073	6,191	5,637	3,694						
Susquehanna,	40,043	40,098	40,354	37,523	36,267	28,658	21,155	16,787	9,960			
Tioga,	49,086	52,313	46,314	36,097	31,044	23,987	16,498	8,987	4,021	1,687		
Union,	17,592	17,820	16,905	15,565	14,145	26,083	22,787	20,796	18,619			
Venango,	42,648	46,640	43,670	47,925	25,043	18,310	17,900	9,470	4,915	3,060	1,130	
Warren,	38,946	37,586	27,981	23,897	19,190	13,671	9,278	4,697	1,976	327	233	
Washington,	22,181	71,155	55,418	48,483	46,805	44,939	41,279	42,784	40,033	34,289	28,293	23,866
Wayne,	30,171	31,010	33,513	33,168	32,289	21,890	11,848	7,063	4,127	4,126	2,563	
Westmoreland,	162,175	112,819	78,086	68,719	53,736	51,726	42,693	38,400	30,540	26,852	22,728	16,018
Wyoming,	17,152	15,891	15,596	14,895	12,540	10,655						
York,	116,413	98,489	87,841	76,134	68,200	57,460	47,010	42,859	38,747	31,988	25,643	37,747

*Centre and Mifflin reported together and credited to Centre in 1790 and 1800.

TABLE II—Population of Pennsylvania by Minor Civil Divisions: 1890 and 1900.

Minor Civil Divisions.	1900.	1890.
ADAMS COUNTY,	34,496	32,436
Arendtsville borough (a),	393	.....
Bendersville borough,	342	370
Herwick borough,	345	381
Berwick township,	532	551
Butler township,	1,450	1,377
Conewago township,	1,181	888
Cumberland township,	1,520	1,583
East Berlin borough,	668	595
Fairfield borough (b),	395	.....
Franklin township (a),	2,090	2,426
Freedom township,	516	561
Germany township,	1,027	964
Gettysburg borough,	3,495	3,221
First ward,	1,168	.....
Second ward,	1,044	.....
Third ward,	1,283	.....
Hamilton township,	630	651
Hamiltonban township (b),	1,598	1,831
Highland township,	491	483
Huntingdon township,	1,543	1,552
Latimore township,	1,150	1,244
Liberty township,	836	761
Littlestown borough,	1,118	991
McSherrystown borough,	1,490	1,020
Menallen township,	1,643	1,598
Mountjoy township,	1,368	1,392
Mt. Pleasant township,	2,006	2,039
New Oxford borough,	663	585
Oxford township,	918	905
Reading township,	1,228	1,368
Straban township,	1,425	1,641
Tyrone township,	1,007	1,060
Union township,	1,076	1,128
York Springs borough,	352	340
ALLEGHENY COUNTY,	775,058	c 551,959
Aleppo township,	616	510
Allegheny city (d),	129,896	105,287
First ward,	7,019	.....
Second ward,	18,726	.....
Third ward,	15,941	.....
Fourth ward,	11,172	.....
Fifth ward,	10,967	.....
Sixth ward,	13,784	.....
Seventh ward,	7,375	.....
Eighth ward,	3,379	.....
Ninth ward,	6,070	.....
Tenth ward,	9,552	.....
Eleventh ward,	11,072	.....
Twelfth ward,	6,906	.....
Thirteenth ward,	6,698	.....
Fourteenth ward,	1,135	.....
Aspinwall borough (e),	1,231	.....
Avalon borough (f),	2,130	804

(a) Arendtsville borough organized from part of Franklin township since 1890.

(b) Fairfield borough organized from part of Hamiltonban township since 1890.

(c) Includes population (8,723) of Beltzhoover, Chartiers, Mansfield and Reynoldton boroughs; Beltzhoover annexed to Pittsburg city, Chartiers and Mansfield taken to form Carnegie borough, and Reynoldton annexed to McKeesport city.

(d) Part of Reserve township annexed since 1890.

(e) Organized from part of O'Hara township since 1890.

(f) Formerly West Bellevue.

TABLE II—Population of Pennsylvania by Minor Civil Divisions: 1890 and 1900—Continued.

Minor Civil Divisions.	1900.	1890.
ALLEGHENY COUNTY—Continued.		
Baldwin township,	8,212	4,860
Bellevue borough,	3,416	1,418
Ben Avon borough (g),	859	.....
Bethel township,	829	663
Braddock borough (h),	15,654	8,561
First ward,	6,078	.....
Second ward,	4,178	.....
Third ward,	2,770	.....
Fourth ward,	2,628	.....
Braddock township (i),	553	7,230
Carnegie borough (k),	7,330	.....
First ward,	3,748	.....
Second ward,	3,582	.....
Chartiers township, (l),	2,996	7,808
Collier township,	3,728	2,961
Coraopolis borough,	2,555	962
Crafton borough (l),	1,927	.....
Crescent township,	622	785
Duquesne borough (m),	9,036	.....
First ward,	3,934	.....
Second ward,	2,030	.....
Third ward,	3,072	.....
East Deer township,	1,955	1,683
East McKeesport borough (n),	873	.....
East Pittsburg borough (o),	2,853	.....
Edgewood borough,	1,139	616
Elizabeth borough,	1,866	1,804
Elizabeth township,	5,886	5,149
Elliott borough (l),	3,846	.....
Emsworth borough (p),	958	.....
Esplen borough (l),	2,364	.....
Etna borough (q),	5,384	3,767
Fawn township,	527	618
Findley township,	1,596	1,711
Forward township,	3,215	2,388
Franklin township,	726	731
Glenfield borough,	905	718
Greentree borough,	678	685
Hampton township,	1,513	1,324
Harmer township,	772	621
Harrison township,	6,320	4,685
Horestead borough,	12,534	7,911
First ward,	2,259	.....
Second ward,	3,832	.....
Third ward,	2,184	.....
Fourth ward,	2,312	.....
Fifth ward,	1,967	.....
Indiana township,	1,068	1,057
Jefferson township,	4,219	3,194
Kilbuck township (r),	1,206	2,143

(g) Organized from part of Kilbuck township since 1890.

(h) Part of Braddock township annexed since 1890.

(i) Part annexed to Braddock borough and parts taken to form North Braddock, Rankin and Swissvale boroughs, and part of East Pittsburg borough, since 1890.

(k) Organized from Chartiers and Mansfield boroughs since 1890.

(l) Crafton, Elliott, Esplen and Sheraden boroughs organized from parts of Chartiers township since 1890.

(m) Duquesne borough organized from part of Mifflin township since 1890.

(n) East McKeesport borough organized from part of North Versailles township since 1890.

(o) Organized from parts of Braddock and Wilkins townships since 1890.

(p) Organized from part of Kilbuck township since 1890.

(q) Parts of Shaler township annexed to Etna and Millvale boroughs since 1890.

(r) Parts taken to form Ben Avon and Emsworth boroughs since 1890.

TABLE II—Population of Pennsylvania by Minor Civil Divisions: 1890 and 1900—Continued.

Minor Civil Divisions.	1900.	1890.
ALLEGHENY COUNTY—Continued.		
Knoxville borough,	3,511	1,723
Leet township,	1,912	1,117
Lincoln township (s),	694	1,332
Lower St. Clair township (t),	4,431	4,302
McCandless township,	1,004	986
McKeesport city (u),	34,227	20,741
First ward,	2,942	
Second ward,	3,369	
Third ward,	4,980	
Fourth ward,	2,202	
Fifth ward,	3,488	
Sixth ward,	5,528	
Seventh ward,	3,882	
Eighth ward,	3,512	
Ninth ward,	921	
Tenth ward,	1,936	
Eleventh ward,	1,467	
McKees Rocks borough (v),	6,352	1,687
Marshall township,	799	960
Mifflin township (m),	12,366	11,144
Millvale borough (q),	6,736	3,509
First ward,	2,516	
Second ward,	2,168	
Third ward,	2,052	
Montooth borough (w),	796	
Moon township,	1,371	1,449
Mt. Oliver borough (t),	2,295	
Neville township,	753	853
North Braddock borough (x),	6,535	
North Fayette township (y),	3,619	2,688
North Versailles township (n),	4,832	2,882
Oakdale borough (y),	1,147	
Oakmont borough,	2,323	1,678
O'Hara township (z),	3,101	3,402
Ohio township,	736	661
Osborn borough,	362	221
Patton township (a),	2,370	2,173
Penn township,	3,407	2,932
Pine township,	658	746
Pitcairn borough (b),	2,601	
Pittsburg city (c),	321,616	238,617
First ward,	2,772	
Second ward,	2,141	
Third ward,	1,369	
Fourth ward,	1,935	
Fifth ward,	4,176	
Sixth ward,	9,628	
Seventh ward,	7,654	
Eighth ward,	8,927	

(a) Port Vue borough organized from part of Lincoln township since 1890.

(t) Mt. Oliver borough organized from part of Lower St. Clair township since 1890.

(u) Reynoldton borough and part of Versailles township annexed since 1890.

(v) McKees Rocks village, included in Stowe township in 1890, incorporated as a borough since 1890.

(m) Duquesne borough organized from part of Mifflin township since 1890.

(q) Parts of Shaler township annexed to Etna and Millvale boroughs since 1890.

(w) Montooth borough organized from part of West Liberty borough since 1890.

(x) Organized from part of Braddock township since 1890.

(y) Oakdale borough organized from parts of North and South Fayette townships since 1890.

(n) East McKeesport borough organized from part of North Versailles township since 1890.

(z) Part taken to form Aspinwall borough since 1890.

(a) Parts taken to form Pitcairn borough and part of Turtle Creek borough since 1890.

(b) Organized from part of Patton township since 1890.

(c) Beltzhoover borough and parts of Sterrett township and Wilksburg borough annexed since 1890.

TABLE II—Population of Pennsylvania by Minor Civil Divisions: 1890 and 1900—Continued.

Minor Civil Divisions.	1900.	1890.
ALLEGHENY COUNTY—Continued.		
Pittsburg city—Continued.		
Ninth ward,	3,802	
Tenth ward,	2,857	
Eleventh ward,	11,883	
Twelfth ward,	10,592	
Thirteenth ward,	21,152	
Fourteenth ward,	22,669	
Fifteenth ward,	5,485	
Sixteenth ward,	14,156	
Seventeenth ward,	14,094	
Eighteenth ward,	11,008	
Nineteenth ward,	17,847	
Twentieth ward,	21,462	
Twenty-first ward,	21,323	
Twenty-second ward,	5,877	
Twenty-third ward,	13,953	
Twenty-fourth ward,	6,648	
Twenty-fifth ward,	7,812	
Twenty-sixth ward,	7,745	
Twenty-seventh ward,	14,296	
Twenty-eighth ward,	5,817	
Twenty-ninth ward,	4,348	
Thirtieth ward,	3,540	
Thirty-first ward,	6,443	
Thirty-second ward,	8,932	
Thirty-third ward,	680	
Thirty-fourth ward,	2,011	
Thirty-fifth ward,	5,246	
Thirty-sixth ward,	3,725	
Thirty-seventh ward,	4,808	
Thirty-eighth ward,	3,325	
Plum township,	2,142	1,682
Port Vue borough (s),	1,803	
Rankin borough (x),	3,775	
Reserve township (d),	3,095	2,941
Richland township,	946	315
Robinson township,	2,341	1,242
Ross township,	2,671	2,202
Scott township,	2,975	2,651
Sewickley borough,	3,568	2,776
First ward,	2,112	
Second ward,	1,456	
Sewickley township,	334	359
Shaler township (q),	3,494	4,969
Sharpsburg borough,	6,842	4,838
Sheraden borough (l),	2,948	
Snowden township,	831	766
South Fayette township (y),	5,548	2,484
South Versailles township,	728	678
Springdale township,	1,007	997
Spring Garden borough,	1,015	720
Sterrett township (e),	555	1,182
Stowe township (v),	2,852	2,029

(s) Port Vue borough organized from part of Lincoln township since 1890.

(x) Organized from part of Braddock township since 1890.

(d) Part annexed to Allegheny city since 1890.

(q) Parts of Shaler township annexed to Etna and Millvale boroughs since 1890.

(l) Crafton, Elliott, Esplen and Sheraden boroughs organized from parts of Chartiers township since 1890.

(y) Oakdale borough organized from parts of North and South Fayette townships since 1890.

(e) Parts annexed to Pittsburg city and Wilkinsburg borough since 1890.

(v) McKees Rocks village, included in Stowe township in 1890, incorporated as a borough since 1890.

(f) Exclusive of population of McKees Rocks village.

TABLE II—Population of Pennsylvania by Minor Civil Divisions: 1890 and 1900—Continued.

Minor Civil Divisions.	1900.	1890.
ALLEGHENY COUNTY—Continued.		
Swissvale borough (x),	1,716	.....
Tarentum borough,	5,472	4,627
First ward,	1,754	.....
Second ward,	1,775	.....
Third ward,	1,943	.....
Turtle Creek borough (s),	3,262	.....
Union township,	1,285	1,417
Upper St. Clair township,	2,693	1,548
Verona borough,	1,904	1,477
Versailles borough (h),	870	.....
Versailles township (l),	1,468	2,262
West Deer township,	1,225	1,801
West Elizabeth borough,	747	719
West Liberty borough (w),	1,281	863
Wilkins township (k),	2,427	2,304
Wilksburg borough (l),	11,886	4,662
First ward,	2,631	.....
Second ward,	4,339	.....
Third ward,	3,916	.....
Wilmerding borough,	4,179	419
ARMSTRONG COUNTY,	52,551	46,747
Apello borough,	2,924	2,156
Applewood borough (m),	122	.....
Atwood borough,	153	185
Bethel township,	839	788
Boggs township,	865	847
Bradys Bend township,	891	1,261
Burrell township,	893	923
Cowanshannock township,	2,697	2,170
Dayton borough,	431	372
East Franklin township (m),	1,860	1,575
Elderton borough,	293	243
Ford City borough (n),	2,870	1,255
Freeport borough,	1,754	1,637
Gilpin township,	1,875	1,156
Hovey township,	241	346
Kiskiminitas township,	2,620	2,452
Kittanning borough,	3,902	3,095
First ward,	1,754	.....
Second ward,	2,148	.....
Kittanning township,	1,396	1,393
Leechburg borough,	2,459	1,921
Madison township,	1,604	1,763
Mahoning township,	1,457	1,256
Manor township (n),	2,583	o 1,604
Manorville borough,	453	392
North Buffalo township,	1,089	1,106
Parkers Landing city,	1,070	1,317
Parks township,	572	704
Perry township,	656	983

(x) Organized from part of Braddock township since 1890.

(s) Organized from parts of Patton and Wilkins townships since 1890.

(h) Organized from part of Versailles township since 1890.

(l) Part taken to form Versailles borough and part annexed to McKeesport city since 1890.

(w) Montooth borough organized from part of West Liberty borough since 1890.

(k) Parts taken to form parts of East Pittsburg and Turtle Creek boroughs since 1890.

(l) Part annexed to Pittsburg city and part of Sterrett township annexed since 1890.

(m) Applewood borough organized from part of East Franklin township since 1890.

(n) Ford City village formerly in Manor township, incorporated as a borough since 1890.

(o) Exclusive of population of Ford City village.

TABLE II—Population of Pennsylvania by Minor Civil Divisions: 1890 and 1900—Continued.

Minor Civil Divisions.	1900.	1890.
ARMSTRONG COUNTY—Continued.		
Pine township,	369	522
Plumcreek township,	1,495	1,788
Queenstown borough,	69	123
Rayburn township (p),	1,582	.....
Redbank township,	2,269	1,892
South Bend township,	875	1,016
South Bethlehem borough,	183	111
South Buffalo township,	1,365	1,634
Sugar Creek township,	885	1,070
Valley township (p),	559	1,602
Washington township,	1,207	1,222
Wayne township,	1,461	1,503
West Franklin township,	965	1,152
Worthington borough,	398	246
BEAVER COUNTY,	56,432	q 50,077
Alliquippa borough (r),	620	.....
Baden borough,	427	390
Beaver borough,	2,348	1,562
Beaver Falls borough,	10,064	9,735
First ward,	1,945	.....
Second ward,	1,635	.....
Third ward,	1,767	.....
Fourth ward,	956	.....
Fifth ward,	2,111	.....
Sixth ward,	1,649	.....
Big Beaver township,	1,380	1,497
Borough township,	612	409
Bridgewater borough,	1,347	1,177
Brighton township,	687	773
Chippewa township,	527	571
College Hill borough (s),	800	.....
Darlington borough,	270	254
Darlington township,	1,235	1,137
Daugherty township (t),	533	.....
Eastvale borough (t),	256	.....
Economy township,	1,062	1,029
Fallston borough,	549	541
Frankfort Springs borough,	128	180
Franklin township,	810	734
Freedom borough (u),	1,783	704
Georgetown borough,	271	274
Glasgow borough,	172	218
Greene township,	1,023	1,111
Hanover township,	1,031	1,213
Harmony township,	650	v 513
Hookstown borough,	259	297
Hopewell township (r),	1,346	1,447
Independence township,	610	932
Industry township,	664	618
Marion township,	380	413
Monaca borough (w),	2,006	1,494

(p) Rayburn township organized from part of Valley township since 1890.

(q) Includes population (411) of St. Clair borough, annexed to Freedom borough.

(r) Alliquippa borough organized from part of Hopewell township since 1890.

(s) College Hill borough organized from part of White township since 1890.

(t) Daugherty township and Eastvale borough organized from parts of North Sewickley and Pulaski townships since 1890.

(v) Includes population (413) of what was erroneously given as Economy borough in 1890.

(u) St. Clair borough annexed since 1890.

(w) Formerly Phillipsburg.

TABLE II—Population of Pennsylvania by Minor Civil Divisions: 1890 and 1900—Continued.

Minor Civil Divisions.	1900.	1890.
BEAVER COUNTY—Continued.		
Moon township,	1,095	1,092
New Brighton borough,	6,820	5,616
First ward,	1,603	
Second ward,	1,754	
Third ward,	1,564	
Fourth ward,	1,839	
New Gallilee borough,	327	320
New Sewickley township,	1,592	1,922
North Sewickley township (t),	1,660	1,154
Ohio township,	939	1,072
Patterson township (x),	433	529
Patterson Heights borough (x),	272	
Pulaski township (t),	728	1,196
Raccoon township,	814	1,012
Rochester borough,	4,688	3,649
First ward,	1,105	
Second ward,	1,230	
Third ward,	1,019	
Fourth ward,	1,334	
Rochester township,	1,661	925
South Beaver township,	930	926
White township (s),	491	1,040
BEDFORD COUNTY,	29,468	28,644
Bedford borough,	2,187	2,242
East ward,	1,142	
West ward,	1,025	
Bedford township,	2,361	2,561
Bloomfield township,	761	913
Broadtop township (y),	3,003	2,370
Coaldale borough,	348	272
Colerain township,	921	1,045
Cumberland Valley township,	1,082	1,108
East Providence township,	1,552	1,475
East St. Clair township,	1,130	1,148
Everett borough,	1,884	1,679
Harrison township,	810	804
Hopewell borough (y),	492	
Hopewell township,	1,394	1,356
Hyndman borough,	1,242	1,066
Junata township,	1,195	1,401
Kimmell township,	526	741
Kling township,	623	638
Liberty township,	1,282	1,332
Lincoln township (z),	469	
Londonderry township,	1,441	1,611
Mann township,	905	891
Manna Choice borough,	312	363
Monroe township,	1,830	1,909
Napier township,	1,683	1,671
New Paris borough,	206	196
Pleasantville borough,	218	257
Rainsburg borough,	219	347
St. Clairsville borough,	102	134
Saxton borough,	937	712

(t) Daugherty township and Eastvale borough organized from parts of North Sewickley and Pulaski townships since 1890.

(x) Patterson Heights borough organized from part of Patterson township since 1890.

(s) College Hill borough organized from part of White township since 1890.

(y) Hopewell borough organized from part of Broadtop township since 1890.

(z) Lincoln township organized from part of Union township since 1890.

TABLE II—Population of Pennsylvania by Minor Civil Divisions: 1890 and 1900—Continued.

Minor Civil Divisions.	1900.	1890.
BEDFORD COUNTY—Continued.		
Schellsburg borough,	312	281
Snakespring township,	724	774
Southampton township,	1,123	1,066
South Woodbury township,	1,525	1,626
Union township (z),	484	910
West Providence township,	1,958	1,710
West St. Clair township,	861	944
Woodbury borough,	226	290
Woodbury township,	871	932
BERKS COUNTY,	159,615	a 127,327
Albany township,	1,316	1,491
Alsace township,	826	(a)
Amity township,	1,372	1,553
Bechtelsville borough (b),	281	.....
Bern township,	1,929	1,935
Bernville borough,	244	265
Bethel township,	1,921	2,129
Birdsboro borough,	2,264	2,261
East ward,	1,468	
West ward,	796	
Boyetown borough,	1,709	1,436
Brecknock township,	946	949
Caernarvon township,	959	942
Centre township,	1,313	1,418
Centerport borough,	141	133
Colebrookdale township,	1,395	1,352
Cumru township,	5,772	3,927
District township,	651	715
Douglass township,	1,028	1,143
Earl township,	909	927
Exeter township,	2,503	2,208
Fleetwood borough,	978	878
Greenwich township,	1,470	1,651
Hamburg borough,	2,315	2,127
North ward,	1,122	
South ward,	1,193	
Heidelberg township,	1,611	1,440
Hereford township,	1,202	1,357
Jefferson township,	800	969
Kutztown borough,	1,328	1,535
Lenhartsville borough,	144	152
Longswamp township,	2,507	2,007
Lower Alsace township,	1,187	(c)
Lower Heidelberg township,	3,896	2,876
Malden Creek township,	1,639	1,775
Marion township,	1,162	1,269
Maxatawney township,	2,407	2,264
Muhlenberg township,	2,069	2,069
North Heidelberg township,	736	854
Oley township,	2,115	2,098
Ontelaunee township,	1,142	1,129
Penn township,	1,164	1,222
Perry township,	1,583	1,575
Pike township,	906	823
Reading city,	78,961	58,661

(z) Lincoln township organized from part of Union township since 1890.

(a) Alsace and Lower Alsace townships (population 1,691) not separately returned in 1890.

(b) Organized from part of Washington township since 1890.

(c) Alsace and Lower Alsace townships not separately returned in 1890.

TABLE II—Population of Pennsylvania by Minor Civil Divisions: 1890 and 1900—Continued.

Minor Civil Divisions.	1900.	1890.
BERKS COUNTY—Continued.		
Reading city—Continued.		
First ward,	3,993	
Second ward,	6,666	
Third ward,	4,717	
Fourth ward,	2,621	
Fifth ward,	3,422	
Sixth ward,	8,011	
Seventh ward,	3,861	
Eighth ward,	3,789	
Ninth ward,	5,464	
Tenth ward,	4,769	
Eleventh ward,	5,460	
Twelfth ward,	6,617	
Thirteenth ward,	6,811	
Fourteenth ward,	4,005	
Fifteenth ward,	3,874	
Sixteenth ward,	4,911	
Richmond township,	1,727	1,916
Robeson township,	2,475	2,483
Rockland township,	1,240	1,423
Ruscombmanor township,	1,212	1,313
Spring township,	4,064	2,544
Tilden township,	1,003	1,082
Topton borough,	542	500
Tulpehocken township,	1,764	1,972
Union township,	1,220	1,317
Upper Bern township,	904	989
Upper Tulpehocken township,	1,006	1,194
Washington township (d),	1,787	2,173
Windsor township,	694	686
Womelsdorf borough,	1,136	1,141
BLAIR COUNTY,	85,099	e 70,866
Allegheny township (f),	1,841	g 1,788
Altoona city,	38,973	30,337
First ward,	3,575	
Second ward,	5,285	
Third ward,	3,296	
Fourth ward,	3,716	
Fifth ward,	3,954	
Sixth ward,	6,625	
Seventh ward,	2,778	
Eighth ward,	7,278	
Ninth ward,	2,466	
Antis township,	2,368	2,060
Bellwood borough,	1,545	1,146
Blair township (f),	1,043	g 1,064
Catharine township,	712	513
Duncansville borough (f),	1,512	1,277
Frankstown township,	1,609	1,505
Freedom township,	1,114	1,140
Gayport borough,	809	867
Greenfield township,	1,427	1,319
Holidaysburg borough,	2,998	2,975
First ward,	778	
Second ward,	766	
Third ward,	533	
Fourth ward,	921	

(d) Part taken to form Bechtelsville borough since 1890.

(e) Includes population (435) of East Tyrone borough, annexed to Tyrone borough.

(f) Duncansville village, formerly in Allegheny and Blair townships, incorporated as a borough since 1890.

(g) Exclusive of population of Duncansville village.

TABLE II—Population of Pennsylvania by Minor Civil Divisions: 1890 and 1900—Continued.

Minor Civil Divisions.	1900.	1890.
BLAIR COUNTY—Continued.		
Huston township,	1,145	1,391
Junata borough (h),	1,709	.....
Junata township,	612	684
Logan township (h),	9,089	7,688
Martinsburg borough,	590	588
Newry borough,	350	335
North Woodbury township,	1,477	1,651
Roaring Spring borough,	1,344	920
Snyder township (l),	2,010	2,011
Taylor township,	1,384	1,116
Tyrone borough (k),	5,847	4,705
First ward,	764	.....
Second ward,	794	.....
Third ward,	998	.....
Fourth ward,	1,017	.....
Fifth ward,	933	.....
Sixth ward,	690	.....
Seventh ward,	651	.....
Tyrone township,	1,119	1,239
Williamsburg borough (l),	935	858
Woodbury township (l),	1,537	m 1,224
BRADFORD COUNTY,	59,403	59,233
Alba borough,	154	163
Albany township,	1,363	1,432
Armenia township,	375	460
Asylum township,	883	1,043
Athens borough,	3,749	3,274
First ward,	1,037	.....
Second ward,	1,015	.....
Third ward,	1,697	.....
Athens township (n),	1,556	4,748
Barclay township,	452	1,426
Burlington borough,	179	166
Burlington township,	836	946
Canton borough,	1,525	1,333
Canton township,	1,867	1,835
Columbia township,	1,222	1,345
Franklin township,	587	626
Granville township,	1,115	1,224
Herrick township,	810	813
Leraysville borough,	375	374
Leroy township,	980	1,013
Litchfield township,	959	946
Monroe borough,	385	496
Monroe township,	1,377	1,596
New Albany borough,	425	287
North Towanda township,	714	753
Orwell township,	1,092	1,021
Overton township,	655	775
Pike township,	1,196	1,308
Ridgebury township,	1,174	1,198
Rome borough,	223	226
Rome township,	868	919

(h) Juniata borough organized from part of Logan township since 1890.

(l) Part annexed to Tyrone borough since 1890.

(k) East Tyrone borough and part of Snyder township annexed since 1890.

(l) Williamsburg village, formerly in Woodbury township, incorporated as a borough since 1890.

(m) Exclusive of population of Williamsburg village.

(n) Sayre borough organized from part of Athens township since 1890.

TABLE II—Population of Pennsylvania by Minor Civil Divisions: 1890 and 1900—Continued.

Minor Civil Divisions.	1900.	1890.
BRADFORD COUNTY—Continued.		
Sayre borough (n),	5,243	.....
First ward,	2,516	
Second ward,	1,446	
Third ward,	1,281	
Sheshequin township,	1,154	1,372
Smithfield township,	1,600	1,630
South Creek township,	900	935
South Waverly borough,	1,215	1,082
Springfield township,	1,267	1,359
Standing Stone township,	703	753
Sylvania borough,	203	241
Terry township,	1,302	1,235
Towanda borough,	4,663	4,169
First ward,	1,381	
Second ward,	1,778	
Third ward,	1,504	
Towanda township,	1,006	1,091
Troy borough,	1,450	1,307
Troy township,	1,435	1,525
Tuscarora township,	1,208	1,357
Ulster township,	927	1,013
Warren township,	1,061	1,124
Wells township,	970	985
West Burlington township,	698	892
Willmot township,	1,444	1,511
Windham township,	860	1,020
Wyalusing borough,	525	438
Wyalusing township,	1,199	1,273
Wysex township,	1,244	1,249
BUCKS COUNTY,	71,190	70,615
Attleboro borough (o),	377	.....
Bedminster township,	2,244	2,385
Bensalem township,	3,046	2,499
Bridgeton township,	731	846
Bristol borough,	7,104	6,553
First ward,	1,723	
Second ward,	2,492	
Third ward,	1,326	
Fourth ward,	1,563	
Bristol township (p),	1,337	1,591
Buckingham township,	2,506	2,544
Doylestown borough,	3,034	2,519
First ward,	1,202	
Second ward,	838	
Third ward,	994	
Doylestown township,	1,764	1,733
Durham township,	1,624	1,783
East Rockhill township (q),	1,055	1,660
Falls township (p),	1,856	2,463
Haycock township,	967	1,218
Hilltown township (r),	2,915	3,032
Hulmeville borough,	454	418
Langhorne borough,	801	727
Langhorne Manor borough (s),	222	.....

(n) Sayre borough organized from part of Athens township since 1890.

(o) Organized from part of Middletown township since 1890.

(p) Part taken to form part of Tullytown borough since 1890.

(q) Part annexed to Perkasio borough since 1890.

(r) Silverdale borough organized from part of Hilltown township since 1890.

(s) Organized from part of Middletown township since 1890.

TABLE II—Population of Pennsylvania by Minor Civil Divisions: 1890 and 1900—Continued.

Minor Civil Divisions.	1900.	1890.
BUCKS COUNTY—Continued.		
Lower Makefield township (t),	1,152	u 1,215
Middletown township (v),	1,383	2,309
Milford township,	2,631	2,725
Morrisville borough,	1,371	1,203
New Britain township,	1,617	1,704
New Hope borough,	1,218	1,143
Newtown borough,	1,463	1,213
Newtown township,	715	759
Nockamixon township,	1,204	1,420
Northampton township,	1,522	2,049
Perkasie borough (w),	1,803	458
Plumstead township,	2,119	2,336
Quakertown borough,	3,014	2,169
First ward,	812	
Second ward,	1,179	
Third ward,	1,023	
Richland township (x),	1,542	2,068
Richlandtown borough (x),	285	
Sellersville borough,	1,247	784
Silverdale borough (r),	255	
Solebury township,	2,082	2,371
Southampton township,	1,411	1,637
Springfield township,	2,242	2,351
Telford borough,	181	125
Tinicum township,	1,700	2,093
Tullytown borough (y),	528	
Upper Makefield township,	1,143	1,236
Warminster township,	973	969
Warrington township,	883	820
Warwick township,	631	709
West Rockhill township,	1,309	1,193
Wrightstown township,	756	838
Yardley borough (t),	714	813
BUTLER COUNTY,		
	56,962	± 55,339
Adams township (a),	1,610	1,817
Allegheny township,	1,004	1,224
Brady township,	721	729
Buffalo township,	1,121	1,131
Butler borough,	10,853	8,734
First ward,	2,597	
Second ward,	2,548	
Third ward,	2,031	
Fourth ward,	1,781	
Fifth ward,	1,896	
Butler township,	1,591	1,297
Centre township,	899	1,065
Cherry township,	1,021	1,433
Clay township,	1,134	1,076
Clearfield township,	813	841

(t) Yardley village, formerly in Lower Makefield township, incorporated as a borough since 1890.

(u) Exclusive of population of Yardley village.

(v) Parts taken to form Attleboro and Langhorne Manor boroughs since 1890.

(w) Part of East Rockhill township annexed since 1890.

(x) Richlandtown organized from part of Richland township since 1890.

(r) Silverdale borough organized from part of Hilltown township since 1890.

(y) Organized from parts of Bristol and Falls township since 1890.

(z) Harrisville borough and Mercer township (population) 1,063 not separately returned in 1890.

(a) Mars and Valencia boroughs organized from parts of Adams township since 1890.

TABLE II—Population of Pennsylvania by Minor Civil Divisions: 1890 and 1900—Continued.

Minor Civil Divisions.	1900.	1890.
BUTLER COUNTY—Continued.		
Clinton township,	900	918
Concord township,	1,086	1,138
Connoquenessing borough (b),	343	.....
Connoquenessing township (b),	960	1,592
Cranberry township,	981	909
Donegal township,	1,204	1,617
Evans City borough,	1,303	637
Fairview borough,	235	303
Fairview township,	1,437	1,996
Forward township,	1,515	1,724
Franklin township,	924	990
Harmony borough,	645	585
Harrisville borough,	319	(s)
Jackson township,	1,406	1,154
Jefferson township,	1,422	1,600
Karna City borough,	285	427
Lancaster township,	834	946
Marion township,	878	965
Mars borough (a),	777	.....
Mercer township,	684	(s)
Middlesex township,	1,541	1,078
Millerstown borough,	960	1,163
Muddy Creek township,	799	785
Oakland township,	940	1,198
Parker township,	1,317	1,710
Penn township,	1,712	1,814
Petrolia borough,	850	546
Portersville borough,	196	190
Prospect borough,	361	343
Saxonburg borough,	307	258
Slipperyrock borough (c),	993	448
Slipperyrock township,	1,013	1,247
Summit township,	1,260	1,287
Valencia borough (a),	149	.....
Venango township,	1,342	1,147
Washington township,	1,508	1,351
West Sunbury borough (d),	254	228
Winfield township,	1,395	1,087
Worth township,	827	939
Zellenople borough,	963	639
CAMBRIA COUNTY,	104,837	e 66,375
Adams township,	2,613	1,037
Allegheny township,	1,342	1,267
Ashville borough,	333	389
Barnesboro borough (f),	1,482	.....
Barr township,	1,336	920
Blacklick township,	1,622	624
Cambria township,	1,160	1,069
Carroll township (g),	2,284	1,226
Carrolltown borough,	790	624
Chest township,	674	508
Chest Springs borough,	202	255

(b) Connoquenessing borough organized from part of Connoquenessing township since 1890.
 (s) Harrisville borough and Mercer township (population 1,083) not separately returned in 1890.

(a) Mars and Valencia boroughs organized from parts of Adams township since 1890.

(c) Formerly Centerville.

(d) Formerly Sunbury.

(e) Includes population (619) of Coopersdale borough, annexed to Johnstown city.

(f) Organized from part of Susquehanna township since 1890.

(g) Parts taken to form parts of Patton and Spangler boroughs since 1890.

TABLE II—Population of Pennsylvania by Minor Civil Divisions: 1890 and 1900—Continued.

Minor Civil Divisions.	1900.	1890.
CAMBRIA COUNTY—Continued.		
Clearfield township (h),	1,135	1,206
Conemaugh township (l),	778	764
Cresson township (k),	1,572	.....
Croyle township (i),	2,185	1,874
Daisytown borough (m),	436	.....
Dale borough (n),	1,503	.....
Dean township,	373	501
East Conemaugh borough,	2,175	1,158
East Taylor township,	698	845
Ebensburg borough,	1,574	1,202
East ward,	528	.....
West ward,	1,016	.....
Elder township (h),	1,504	711
Ferndale borough (o),	224	.....
Franklin borough,	961	662
Gallitzin borough,	2,759	2,392
Gallitzin township,	1,473	1,076
Hastings borough,	1,621	1,070
Jackson township,	2,006	987
Johnstown city (p),	35,936	21,865
First ward,	2,253	.....
Second ward,	1,118	.....
Third ward,	595	.....
Fourth ward,	1,115	.....
Fifth ward,	2,036	.....
Sixth ward,	2,635	.....
Seventh ward,	2,627	.....
Eighth ward,	960	.....
Ninth ward,	2,429	.....
Tenth ward,	1,692	.....
Eleventh ward,	1,127	.....
Twelfth ward,	1,420	.....
Thirteenth ward,	1,254	.....
Fourteenth ward,	1,726	.....
Fifteenth ward,	2,238	.....
Sixteenth ward,	3,011	.....
Seventeenth ward,	2,774	.....
Eighteenth ward,	1,111	.....
Nineteenth ward,	1,255	.....
Twentieth ward,	1,701	.....
Twenty-first ward,	809	.....
Lilly borough,	1,276	915
Loretto borough,	240	236
Lower Yoder township (q),	2,194	4,290
Munster township,	429	400
Patton borough (r),	2,651	.....
Portage borough (s),	816	564
Portage township (t),	3,018	n 1,246

(h) Part taken to form part of Patton borough since 1890.

(i) Part taken to form part of Daisytown borough since 1890.

(k) Organized from part of Washington township since 1890.

(l) Part taken to form Summerhill borough since 1890.

(m) Organized from parts of Conemaugh and Stony creek townships since 1890.

(n) Organized from part of Stonycreek township since 1890.

(o) Organized from part of Upper Yoder township since 1890.

(p) Coopersdale borough (population 619 in 1890), Morrellville borough, given as Morrellville village in Lower Yoder township in 1890 (population 2,827 in 1890), and part of Stonycreek township annexed since 1890.

(q) Part taken to form part of Westmont borough and part annexed to Johnstown city since 1890.

(r) Organized from parts of Carroll, Clearfield and Elder townships since 1890.

(s) Portage village, formerly in Portage township, incorporated as a borough since 1890.

(t) Exclusive of population of Portage village.

TABLE II—Population of Pennsylvania by Minor Civil Divisions: 1890 and 1900—Continued.

Minor Civil Divisions.	1900.	1890.
CAMBRIA COUNTY—Continued.		
Reade township,	2,980	2,235
Richland township (m),	1,378	920
Rosedale borough (n),	386	.....
Roxbury borough (o),	808	.....
Scalp Level borough (p),	450	.....
South Fork borough,	2,635	1,295
First ward,	1,311	.....
Second ward,	1,324	.....
Spangler borough (q),	1,616	.....
Stonycreek township (r),	1,275	1,788
Summerhill borough (s),	591	.....
Summerhill township,	704	602
Susquehanna township (t),	1,898	1,160
Tunnelhill borough,	674	730
Upper Yoder township (u),	943	1,325
Washington township (v),	1,236	1,663
Westmont borough (w),	499	.....
West Taylor township (x),	1,206	1,277
White township,	760	690
Wilmore borough,	264	350
CAMERON COUNTY,	7,048	7,238
Driftwood borough,	509	628
Emporium borough,	2,463	2,147
East ward,	816	.....
Middle ward,	793	.....
West ward,	854	.....
Gibson township,	822	948
Grove township,	696	784
Lumber township,	568	907
Portage township,	246	226
Shippen township,	1,744	1,598
CARBON COUNTY,	44,510	38,624
Banks township (y),	4,133	4,461
Beaver Meadow borough (y),	1,378	.....
East Mauch Chunk borough,	3,458	2,772
First ward,	1,507	.....
Second ward,	1,250	.....
Third ward,	701	.....
East Penn township,	1,182	1,109
East Side borough (z),	210	.....
Franklin township,	2,342	2,040
Kidder township (z),	651	992

(m) Part taken to form Scalp Level borough since 1890.

(n) Organized from part of West Taylor township since 1890.

(o) Organized from part of Upper Yoder township since 1890.

(p) Organized from part of Richland township since 1890.

(q) Organized from parts of Carroll and Susquehanna townships since 1890.

(r) Parts taken to form Dale borough and part of Daisytown borough, and part annexed to Johnstown city, since 1890.

(s) Organized from part of Croyle township since 1890.

(t) Parts taken to form Barnesboro borough and part of Spangler borough since 1890.

(u) Parts taken to form Ferndale and Roxbury boroughs and part of Westmont borough since 1890.

(v) Part taken to form Cresson township since 1890.

(w) Organized from parts of Upper and Lower Yoder townships since 1890.

(x) Part taken to form Rosedale borough since 1890.

(y) Beaver Meadow borough organized from part of Banks township since 1890.

(z) East Side borough organized from part of Kidder township since 1890.

TABLE II—Population of Pennsylvania by Minor Civil Divisions: 1890 and 1900—Continued.

Minor Civil Divisions.	1900.	1890.
CARBON COUNTY—Continued.		
Lansford borough,	4,888	4,004
East ward, 1,685		
Middle ward, 1,418		
West ward, 1,785		
Lausanne township,	942	126
Lehigh township,	619	565
Lehighton borough,	4,629	2,959
First ward, 1,695		
Second ward, 1,102		
Third ward, 1,833		
Lower Towamensing township,	2,507	1,736
Mahoning township,	2,501	2,248
Mauch Chunk borough,	4,029	4,101
First ward, 1,893		
Second ward, 2,062		
Third ward, 554		
Mauch Chunk township,	2,596	2,448
Packer township,	684	665
Parryville borough,	723	606
Penn Forest township,	498	627
Summit Hill borough,	2,986	2,816
First ward, 645		
Second ward, 623		
Third ward, 1,293		
Fourth ward, 435		
Towamensing township,	914	963
Weatherly borough,	2,471	2,961
First ward, 794		
Second ward, 491		
Third ward, 741		
Fourth ward, 445		
Weissport borough,	601	456
CENTRE COUNTY,	42,894	42,269
Bellefonte borough,	4,216	2,946
North ward, 1,892		
South ward, 1,596		
West ward, 728		
Benner township,	1,242	1,222
Boggs township,	1,899	2,042
Burnside township,	444	530
Centre Hall borough,	537	441
College township (a),	1,140	1,666
Curtin township,	543	546
Ferguson township,	1,512	1,748
Gregg township,	2,098	1,688
Haines township,	1,400	1,490
Halfmoon township,	624	748
Harris township,	826	969
Howard borough,	563	554
Howard township,	819	940
Huston township,	750	766
Liberty township,	1,100	1,944
Marion township,	586	611
Miles township,	1,347	1,438
Milesburg borough,	594	714
Millheim borough,	612	700
Patton township,	924	1,045
Penn township,	880	978

(a) State College borough organized from part of College township since 1890.

TABLE II—Population of Pennsylvania by Minor Civil Divisions: 1890 and 1900—Continued.

Minor Civil Divisions.	1900.	1890.
CENTRE COUNTY—Continued.		
Phillipsburg borough,	3,266	3,245
First ward,	824	
Second ward,	1,331	
Third ward,	1,111	
Potter township,	1,765	1,764
Rush township (b),	2,430	2,328
Snow Shoe township,	2,786	2,397
South Phillipsburg borough (b),	497	
Spring township,	2,921	3,190
State College borough (a),	851	
Taylor township,	564	577
Union township,	846	880
Unionville borough,	860	848
Walker township,	1,270	1,333
Worth township,	732	840
CHESTER COUNTY,	96,695	89,377
Atglen borough,	404	397
Avondale borough (c),	640	
Birmingham township,	464	458
Cain township,	917	1,053
Charlestown township,	737	790
Coatesville borough,	5,721	3,680
Downingtown borough,	2,133	1,920
East ward,	1,058	
West ward,	1,045	
East Bradford township,	915	1,043
East Brandywine township,	739	995
East Cain township,	231	256
East Coventry township,	1,148	1,219
East Fallowfield township,	1,847	1,505
East Goshen township,	653	684
East Marlboro township,	1,280	1,327
East Nantmeal township,	728	837
East Nottingham township,	1,313	1,305
East Pikeland township,	706	823
Easttown township,	1,910	1,682
East Vincent township,	1,238	1,285
East Whiteland township,	1,273	1,157
Elk township,	722	789
Franklin township,	754	791
Highland township,	833	910
Honeybrook borough (d),	609	514
Honeybrook township (d),	1,268	e 1,362
Hopewell borough,	182	213
Kennett township,	1,144	1,153
Kennett Square borough,	1,516	1,326
London Britain township,	607	607
Londonderry township,	648	671
London Grove township (f),	1,828	2,613
Lower Oxford township,	1,366	1,384
Malvern borough,	975	641
New Garden township,	1,924	2,126
Newlin township,	633	680
New London township,	696	789

(b) South Phillipsburg borough organized from part of Rush township since 1890.

(a) State College borough organized from part of College township since 1890.

(c) Organized from part of London Grove township since 1890.

(d) Honeybrook village, formerly in Honeybrook township, incorporated as a borough in 1891.

(e) Exclusive of population of Honeybrook village.

(f) Parts taken to form Avondale and West Grove boroughs since 1890.

TABLE II—Population of Pennsylvania by Minor Civil Divisions: 1890 and 1900—Continued.

Minor Civil Divisions.	1900.	1890.
CHESTER COUNTY—Continued.		
North Coventry township,	1,664	1,606
Oxford borough,	2,032	1,711
Parkeburg borough,	1,788	1,514
Penn township,	608	632
Pennsbury township,	709	773
Phoenixville borough,	9,196	8,514
First ward,	1,780	
Second ward,	1,906	
Third ward,	1,626	
Fourth ward,	1,783	
Fifth ward,	1,319	
Sixth ward,	783	
Pocopson township,	478	512
Sadsbury township,	942	843
Schuylkill township,	1,220	1,254
South Coventry township,	421	463
Spring City borough,	2,566	1,797
First ward,	684	
Second ward,	433	
Third ward,	901	
Fourth ward,	696	
Thornbury township,	222	251
Tredyffrin township,	2,926	2,549
Upper Oxford township,	1,063	1,096
Upper Uwchlan township,	716	824
Uwchlan township,	596	639
Valley township,	1,079	1,072
Wallace township,	683	662
Warwick township,	1,217	1,487
West Bradford township,	1,408	1,281
West Brandywine township,	766	723
West Caln township,	1,201	1,146
West Chester borough,	9,524	8,028
West Fallowfield township,	1,069	1,039
West Gooshen township,	1,066	1,111
West Grove borough (g),	929	
West Marlboro township,	1,157	1,041
West Nantmeal township,	904	935
West Nottingham township,	777	817
West Pikeland Township,	1,025	664
West Sadsbury township,	320	774
Westtown township,	694	895
West Vincent township,	1,094	1,081
West Whiteland township,	1,046	1,096
Willistown township,	1,143	1,390
CLARION COUNTY,		
	34,233	36,802
Ashland township,	872	1,268
Beaver township,	1,738	1,969
Brady township,	200	237
Callensburg borough,	248	241
Clarion borough,	2,004	2,164
Clarion township,	1,143	1,183
Curtisville borough,	131	154
East Brady borough,	1,233	1,228
Edenburg borough,	704	751
Elk township,	1,049	1,233
Farmington township,	2,246	2,598
Highland township,	657	624
Knox township,	836	838

(g) Organized from part of London Grove township since 1890.

TABLE II—Population of Pennsylvania by Minor Civil Divisions: 1890 and 1900—
Continued.

Minor Civil Divisions.	1900.	1890.
CLARION COUNTY—Continued.		
Licking township,	953	914
Limestone township,	1,381	1,457
Madison township,	1,674	1,759
Millcreek township,	829	842
Monroe township,	932	1,047
New Bethlehem borough,	1,269	1,028
Paint township,	562	600
Perry township,	1,886	1,706
Piney township,	583	742
Porter township,	1,553	1,861
Redbank township,	1,961	2,035
Richland township,	1,410	1,869
Rimersburg borough,	487	360
St. Petersburg borough,	482	655
Salem township,	1,060	1,147
Shippenville borough,	313	336
Sligo borough,	505	496
Strattanville borough,	262	331
Toby township,	1,048	1,161
Washington township,	1,493	1,505
West Millville borough,	559	376
CLEARFIELD COUNTY,		
	80,614	h 69,585
Becaria township (i),	2,924	3,021
Bell township,	1,583	1,484
Bigler township,	2,675	1,841
Bloom township,	570	364
Boggs township,	1,024	835
Bradford township,	2,075	1,981
Brady township (k),	2,638	1,918
Brislin borough,	666	1,508
Burnside borough,	647	282
Burnside township,	1,696	1,614
Chest township (l),	1,022	1,314
Chester Hill borough,	710	563
Clearfield borough (m),	5,061	2,248
First ward,	2,228	
Second ward,	1,669	
Third ward,	1,184	
Coalport borough,	938	855
Cooper township,	4,629	2,276
Covington township,	695	747
Curwensville borough,	1,937	1,684
First ward,	1,093	
Second ward,	844	
Decatur township,	3,810	4,779
Dubois borough,	9,375	6,149
First ward,	3,454	
Second ward,	2,531	
Third ward,	1,567	
Fourth ward,	1,833	
Ferguson township,	914	981
Girard township,	570	587
Glen Hope borough,	220	286
Goshen township,	501	476
Graham township,	626	696

(h) Includes population (621) of West Clearfield borough, annexed to Clearfield boroughs.

(i) Irvona borough organized from part of Becaria township since 1890.

(k) Troutville borough organized from part of Brady township since 1890.

(l) Westover borough organized from part of Chest township since 1890.

(m) West Clearfield borough annexed to Clearfield borough as Third ward since 1890.

TABLE II—Population of Pennsylvania by Minor Civil Divisions: 1890 and 1900—Continued.

Minor Civil Divisions.	1900.	1890.
CLEARFIELD COUNTY—Continued.		
Grampian borough (n),	800	219
Greenwood township (o),	806	566
Gulich township,	1,071	1,300
Houtsdale borough,	1,482	2,221
Huston township,	1,974	2,443
Irvana borough (l),	723	.....
Jordan township,	1,224	1,415
Karthauss township,	1,066	1,363
Knox township,	964	810
Lawrence township,	2,370	2,773
Lumber City borough,	224	266
Mahaffey borough,	741	627
Morris township,	4,460	3,297
Newburg borough,	314	354
New Washington borough,	213	173
Osceola borough (p),	2,030	1,720
Penn township,	840	806
Pike township,	1,575	1,445
Ramey borough (o),	806	.....
Sandy township,	2,223	2,152
Troutville borough (k),	308	.....
Union township,	944	639
Wallaceton borough,	289	260
Westover borough,	654	.....
Woodward township,	2,169	5,596
CLINTON COUNTY,	29,197	28,685
Allison township (q),	322	r 200
Bald Eagle township,	679	812
Beech Creek borough,	449	437
Beech Creek township,	627	706
Castanea township,	299	424
Chapman township,	1,266	1,128
Colebrook township,	496	496
Crawford township,	420	440
Dunstable township,	394	449
East Keating township,	225	229
Flemington borough (q),	864	912
Gallagher township,	357	359
Greene township,	1,221	1,218
Grugan township,	293	229
Lamar township,	1,508	1,393
Ledy township,	663	677
Lock Haven city,	7,210	7,368
First ward,	2,090	.....
Second ward,	1,533	.....
Third ward,	1,571	.....
Fourth ward,	2,016	.....
Logan township,	853	923
Loganton borough,	422	325
Mill Hall borough,	1,010	508
Noyes township,	425	1,054
Pine Creek township,	966	919
Porter township,	870	1,023

(n) Formerly Pennville.

(o) Ramey borough organized from part of Gulich township since 1890.

(l) Irvana borough organized from part of Becaria township since 1890.

(p) Formerly Osceola Mills.

(k) Troutville borough organized from part of Brady township since 1890.

(q) Flemington village, formerly in Allison township, incorporated as a borough since 1890.

(r) Exclusive of population of Flemington village.

TABLE II—Population of Pennsylvania by Minor Civil Divisions: 1890 and 1900—Continued.

Minor Civil Divisions.	1900.	1890.
CLINTON COUNTY—Continued.		
Renovo borough,	4,083	4,154
East ward, 1,549		
Middle ward, 1,114		
West ward, 1,419		
South Renovo borough,	1,225	125
Wayne township,	681	712
West Keating township,	255	253
Woodward township,	937	1,063
COLUMBIA COUNTY,	39,896	36,832
Beaver township,	886	1,039
Benton borough (s),	635	.....
Benton township (s),	857	1,352
Berwick borough,	3,916	2,701
Bloomsburg town (t),	6,170	4,635
Briar Creek township,	1,833	1,292
Catawissa borough (u),	2,023	1,809
Catawissa township (u),	590	v 539
Centre township,	1,189	1,195
Centralia borough,	2,048	2,761
Cleveland township (w),	899	.....
Conyngham township,	3,037	2,739
Fishing Creek township (x),	1,181	1,447
Franklin township,	549	522
Greenwood township (y),	1,807	1,876
Hemlock township,	927	946
Jackson township,	700	738
Locust township (z),	1,200	1,973
Madison township,	1,025	1,072
Main township,	652	595
Mifflin township,	1,043	1,022
Millville borough (y),	593	.....
Montour township,	618	638
Mt. Pleasant township,	722	786
Orange township (a),	446	1,000
Orangeville borough (a),	429	.....
Pine township,	976	965
Roaring Creek township,	681	580
Scott township,	1,281	1,373
Stillwater borough (x),	177	.....
Sugarloaf township,	1,376	1,337
CRAWFORD COUNTY,	63,643	b 65,324
Athens township,	1,106	1,244
Beaver township,	1,018	1,131
Bloomfield township,	1,244	1,367
Blooming Valley borough,	177	206
Cambridge township,	728	690

(s) Benton borough organized from part of Benton township since 1890.

(t) Erroneously returned as Bloom township, co-extensive with Bloomsburg borough, in 1890.

(u) Catawissa village, formerly in Catawissa township, incorporated as a borough since 1890.

(v) Exclusive of population of Catawissa village.

(w) Organized from part of Locust township since 1890.

(x) Stillwater borough organized from part of Fishing Creek township since 1890.

(y) Millville borough organized from part of Greenwood township since 1890.

(z) Part taken to form Cleveland township since 1890.

(a) Orangeville borough organized from part of Orange township since 1890.

(b) Includes population (2616) of Mead township.

TABLE II—Population of Pennsylvania by Minor Civil Divisions: 1890 and 1900—Continued.

Minor Civil Divisions.	1900.	1890.
CRAWFORD COUNTY—Continued		
Cambridge Springs borough (c),	1,495	912
Centreville borough,	260	274
Cochrannton borough,	640	665
Conneaut township,	1,477	1,559
Conneaut Lake borough (d),	343	291
Conneautville borough,	920	757
Cussewago township,	1,264	1,468
East Fairfield township,	544	573
East Fallowfield township,	1,082	1,199
East Mead township (e),	831	.....
Fairfield township,	767	841
Geneva borough,	215	293
Greenwood township,	1,320	1,465
Hartstown borough,	158	160
Hayfield township,	1,434	1,623
Hydetown borough,	337	247
Linesville borough,	661	552
Meadville city,	10,291	9,520
First ward,	2,643	.....
Second ward,	2,669	.....
Third ward,	2,700	.....
Fourth ward,	2,289	.....
North Shenango township,	711	804
Oil Creek township,	1,307	1,489
Pine township,	336	361
Randolph township,	1,774	1,906
Riceville borough,	207	245
Richmond township,	1,196	1,384
Rockdale township,	1,149	1,309
Rome township,	1,324	1,353
Sadsbury township,	755	845
Saegerstown borough,	607	745
South Shenango township,	835	909
Sparta township,	1,143	1,209
Spartansburg borough,	488	516
Spring township,	1,391	1,573
Springboro borough,	603	490
Steuben township,	925	997
Summerhill township,	950	1,040
Summit township,	958	1,008
Titusville city,	8,244	8,073
First ward,	2,564	.....
Second ward,	3,228	.....
Third ward,	842	.....
Fourth ward,	1,600	.....
Townville borough,	327	358
Troy township,	1,436	1,493
Union township,	444	514
Vallonia borough,	533	548
Venango borough,	233	278
Venango township,	495	536
Vernon township,	1,854	2,014
Wayne township,	1,366	1,573
West Fallowfield township,	361	364
West Mead township (e),	1,775	.....
West Shenango township,	277	378
Woodcock borough,	109	140
Woodcock township,	1,187	1,283

(c) Formerly Cambridge.

(d) Formerly Evansburg.

(e) East and West Mead townships organized from Mead township since 1890.

TABLE II—Population of Pennsylvania by Minor Civil Divisions: 1890 and 1900—Continued.

Minor Civil Divisions.	1900.	1890.
CUMBERLAND COUNTY,	50,844	47,271
Camp Hill borough,	360	191
Carlisle borough,	9,626	7,620
First ward,	2,721	
Second ward,	1,450	
Third ward,	2,120	
Fourth ward,	2,335	
Cooke township,	242	328
Dickinson township,	1,559	1,731
East Pennsboro township,	2,651	2,751
Frankford township,	1,404	1,464
Hampden township,	849	964
Hopewell township,	892	1,027
Lower Allen township,	1,592	1,018
Lower Mifflin township (g),	630	
Mechanicsburg borough,	3,841	3,691
First ward,	560	
Second ward,	939	
Third ward,	646	
Fourth ward,	611	
Fifth ward,	785	
Middlesex township,	1,363	1,766
Monroe township,	1,631	1,744
Mt. Holly Springs borough,	1,328	1,190
Newburg borough,	340	376
New Cumberland borough,	1,035	754
Newton township,	1,614	1,713
Newville borough,	1,655	1,562
North ward,	872	
South ward,	783	
North Middleton township,	2,002	994
Penn township,	1,446	1,415
Shippensburg borough,	3,228	2,188
East ward,	2,194	
West ward,	1,034	
Shippensburg township,	595	744
Shiremanstown borough,	504	432
Silver Spring township,	1,804	2,006
Southampton township,	1,716	1,917
South Middleton township,	2,639	2,641
Upper Allen township,	1,069	1,294
Upper Mifflin township (g),	607	
West Pennsboro township,	2,042	2,263
DAUPHIN COUNTY,	114,443	96,977
Berrysburg borough,	398	426
Conewago township,	830	872
Dauphin borough,	566	740
Derry township,	2,232	2,288
East Hanover township,	1,310	1,428
Elizabethville borough (h),	838	676
Gratz borough,	489	490
Halifax borough,	618	515
Halifax township,	1,155	1,208
Harrisburg city (i),	50,167	39,385
First ward,	3,909	
Second ward,	4,269	

(f) Includes population (1,338) of Mifflin township.

(g) Lower and Upper Mifflin townships organized from Mifflin township since 1890.

(h) Elizabethville village, formerly in Washington township, incorporated as a borough since 1890.

(i) Part of Susquehanna township annexed since 1890.

TABLE II—Population of Pennsylvania by Minor Civil Divisions: 1890 and 1900—Continued.

Minor Civil Divisions.	1900.	1890.
DAUPHIN COUNTY—Continued.		
Harrisburg city—Continued.		
Third ward,	2,286	
Fourth ward,	3,641	
Fifth ward,	4,312	
Sixth ward,	11,766	
Seventh ward,	7,198	
Eighth ward,	4,435	
Ninth ward,	6,455	
Tenth ward,	1,906	
Hummelstown borough,	1,729	1,486
Jackson township,	963	1,137
Jefferson township,	286	317
Londonderry township (k),	1,385	2,351
Lower Paxton township,	1,421	1,517
Lower Swatara township,	1,993	1,764
Lykens borough,	2,762	2,450
East ward,	920	
West ward,	1,842	
Lykens township,	1,255	1,242
Middle Paxton township,	1,265	1,327
Middletown borough,	5,608	5,080
First ward,	1,954	
Second ward,	2,006	
Third ward,	1,648	
Mifflin township,	534	546
Millersburg borough,	1,675	1,527
Penbrook borough (l),	864	
Reed township,	275	267
Royalton borough (k),	1,106	
Rush township,	136	151
South Hanover township,	923	1,062
Steelton borough,	12,086	9,250
First ward,	2,134	
Second ward,	1,958	
Third ward,	3,713	
Fourth ward,	1,355	
Fifth ward,	2,896	
Susquehanna township (m),	3,622	3,653
Swatara township,	4,816	3,329
Uniontown borough,	359	333
Upper Paxton township,	1,444	1,494
Washington township (n),	970	o 1,022
Wayne township,	436	512
West Hanover township,	1,010	1,013
Wiconisco township,	2,674	2,280
Williams township,	1,290	1,485
Williamstown borough,	2,934	2,324
DELAWARE COUNTY,	94,762	p 74,683
Aldar borough (q),	296	
Aston township,	2,641	2,454
Bethel township,	580	595

(k) Royalton borough organized from part of Londonderry township since 1890.

(l) Organized from part of Susquehanna township since 1890.

(m) Part annexed to Harrisburg city and part taken to form Penbrook borough since 1890.

(n) Elizabeth village, formerly in Washington township, incorporated as a borough since 1890.

(o) Exclusive of population of Elizabeth village.

(p) Includes population (11,606) of Eddystone and Ridley Park boroughs and and Ridley township (not separately returned in 1890) and South Chester borough (annexed to Chester city since 1890.)

(q) Organized from part of Upper Darby township since 1890.

TABLE II—Population of Pennsylvania by Minor Civil Divisions: 1890 and 1900—Continued.

Minor Civil Divisions.	1900.	1890.
DELAWARE COUNTY—Continued.		
Birmingham township,	733	919
Chester city (r),	33,988	30,236
First ward,	1,961	
Second ward,	3,357	
Third ward,	2,739	
Fourth ward,	2,206	
Fifth ward,	2,952	
Sixth ward,	3,513	
Seventh ward,	4,446	
Eighth ward,	3,137	
Ninth ward,	3,162	
Tenth ward,	2,426	
Eleventh ward,	3,089	
Chester township,		578
Clifton Heights borough,	2,330	1,820
Collingdale borough (s),	603	
Colwyn borough (t),	1,226	
Concord township,	1,471	1,276
Darby borough (s),	3,429	2,972
Darby township (u),	1,338	2,631
Eddystone borough,	776	(v)
Edgemont borough,	552	567
Glenolden borough (w),	873	
Haverford township,	2,414	1,733
Lansdowne borough (x),	2,630	875
Lower Chichester township (y),	1,425	2,292
Marcus Hook borough (y),	1,209	
Marple township,	812	834
Media borough,	3,075	2,736
Middletown township,	3,241	3,257
Morton borough (z),	889	821
Nether Providence township,	2,033	1,817
Newtown township,	728	648
Norwood borough (a),	1,286	
Prospect Park borough (a),	1,050	
Radnor township,	5,474	3,799
Ridley township (b),	1,973	(v)
Ridley Park borough,	1,334	(v)
Rutledge borough,	369	260
Sharon Hill borough (s),	1,068	
Springfield township (c),	889	d 1,615
Swarthmore borough (e),	908	
Thornbury township,	1,864	926
Tinicum township,	472	186

(r) South Chester borough (population 7,076 in 1890) annexed since 1890.

(s) Collingdale and Sharon Hill boroughs organized from parts of Darby borough since 1890.

(t) Organized from part of Darby township since 1890.

(u) Parts taken to form Colwyn and Yeadon boroughs and part of Glenolden borough since 1890.

(v) Eddystone and Ridley Park boroughs and Ridley township (population 4,529) not separately returned in 1890.

(w) Organized from parts of Darby and Ridley townships since 1890.

(x) Formerly Lansdowne village, in Upper Darby township; incorporated as a borough since 1890.

(y) Marcus Hook borough organized from part of Lower Chichester township since 1890.

(z) Formerly Morton village, in Springfield township; incorporated as a borough since 1890.

(a) Organized from part of Ridley township since 1890.

(b) Parts taken to form Norwood and Prospect Park boroughs and part of Glenolden borough since 1890.

(c) Included Morton village (now borough) in 1890. Part taken to form Swarthmore borough since 1890.

(d) Exclusive of population of Morton village.

(e) Organized from part of Springfield township since 1890.

TABLE II—Population of Pennsylvania by Minor Civil Divisions: 1890 and 1900—Continued.

Minor Civil Divisions.	1900.	1890.
DELAWARE COUNTY—Continued.		
Upland borough,	2,131	2,275
Upper Chichester township,	601	564
Upper Darby township (f),	3,821	g 3,898
Upper Providence township,	1,053	1,013
Yeadon borough (t),	689	.....
	32,903	22,239
ELK COUNTY,		
Benezette township,	1,365	1,025
Benzinger township,	2,294	2,733
Fox township,	3,221	2,951
Highland township,	1,415	849
Horton township,	2,855	2,204
Jay township,	1,048	953
Johnsonburg borough (h),	3,894	1,280
Jones township,	3,663	2,845
Millstone township,	1,044	357
Ridgway borough,	3,515	1,908
Ridgway township (h),	2,161	i 1,961
St. Marys borough,	4,295	1,745
Spring Creek township,	2,133	1,403
	36,473	56,074
ERIE COUNTY,		
Albion borough,	695	366
Amity township,	935	912
Concord township,	904	991
Conneaut township,	1,329	1,386
Corry city,	5,369	5,677
First ward,	1,236	
Second ward,	877	
Third ward,	1,803	
Fourth ward,	1,453	
Edinboro borough,	691	1,107
Elgin borough,	138	169
Elk Creek township,	1,362	1,325
Erie city,	52,733	40,634
First ward,	8,490	
Second ward,	12,178	
Third ward,	9,303	
Fourth ward,	8,256	
Fifth ward,	7,005	
Sixth ward,	7,501	
Fairview borough,	327	305
Fairview township,	1,241	1,295
Franklin township,	888	963
Girard borough,	954	636
Girard township,	2,126	2,230
Greene township,	1,406	1,511
Greenfield township,	1,001	1,432
Harborcreek township,	1,687	1,080
Leboeuf township,	1,079	1,215
Lockport borough,	225	240
McKean township,	1,247	1,330
Middleboro borough,	207	195

(f) Included Lansdowne village (new borough) in 1890. Part taken to form Aldan borough since 1890.

(g) Exclusive of population of Lansdowne village.

(t) Organized from part of Darby township since 1890.

(h) Johnsonburg village, formerly in Ridgway township, incorporated as a borough since 1890.

(i) Exclusive of population of Johnsonburg village.

TABLE II—Population of Pennsylvania by Minor Civil Divisions: 1890 and 1900—Continued.

Minor Civil Divisions.	1900.	1890.
ERIE COUNTY—Continued.		
Mill Creek township,	3,891	3,279
Mill Village borough,	321	320
Northeast borough,	2,068	1,538
First ward,	1,076	
Second ward,	992	
Northeast township,	1,962	2,124
Springfield borough (k),	324	
Springfield township (k),	1,451	1,642
Summit township,	871	903
Union township,	1,258	1,366
Union City borough,	3,104	2,261
Venango township,	1,318	1,351
Washington township,	1,706	1,790
Waterford borough,	767	838
Waterford township,	1,457	1,537
Wattsburg borough,	351	382
Wayne township,	1,081	1,124
FAYETTE COUNTY,	110,412	80,006
Bellevernon borough,	1,901	1,147
Bridgeport borough,	1,805	1,030
Brownsville borough,	1,552	1,417
Brownsville township,	291	252
Bullskin township,	4,120	3,519
Connellsville borough,	7,160	5,629
First ward,	1,159	
Second ward,	1,982	
Third ward,	2,078	
Fourth ward,	1,941	
Connellsville township,	8,653	2,166
Dawson borough,	825	668
Dunbar borough,	1,662	1,381
Dunbar township,	13,733	10,503
Fairchance borough,	1,219	1,092
Fayette City borough,	1,596	931
Franklin township,	2,817	1,668
George township (l),	4,295	3,478
German township,	5,154	1,770
Henry Clay township (m),	1,208	1,311
Jefferson township,	2,896	1,656
Lower Tyrone township,	2,360	2,153
Luzerne township,	1,155	1,849
Markleysburg borough (n),	210	
Masontown borough,	466	391
Menallen township,	2,079	1,392
New Haven borough,	1,532	1,221
Nicholson township,	1,324	1,483
North Union township,	9,617	5,099
Ohlappyle borough (o),	423	
Perry township,	4,419	1,623
Point Marion borough (p),	575	
Redstone township,	1,187	1,122
Saltlick township,	1,415	1,339

(k) Springfield borough organized from part of Springfield township since 1890.

(l) Part taken to form Smithfield borough since 1890.

(m) Part taken to form Markleysburg borough since 1890.

(n) Organized from part of Henry Clay township since 1890.

(o) Ohlappyle borough organized from part of Stewart township since 1890.

(p) Point Marion borough organized from part of Springhill township since 1890.

TABLE II—Population of Pennsylvania by Minor Civil Divisions: 1890 and 1900—Continued.

Minor Civil Divisions.	1900.	1890.
FAYETTE COUNTY—Continued.		
Smithfield borough (q),	525	.....
South Union township,	4,317	3,740
Springfield township,	2,077	1,704
Springhill township (p),	1,762	1,720
Stewart township (o),	1,258	1,594
Uniontown borough,	7,244	6,359
First ward,	1,023	
Second ward,	2,020	
Third ward,	2,135	
Fourth ward,	2,166	
Upper Tyrone township,	6,124	4,718
Washington township,	2,708	1,283
Wharton township,	1,619	1,599
FOREST COUNTY,	11,039	8,483
Barnett township,	1,269	850
Green township,	1,159	857
Harmony township,	978	645
Hickory township,	895	1,099
Howe township,	1,670	1,376
Jenks township,	2,423	1,753
Kingsley township,	1,169	779
Tionesta borough,	815	677
Tionesta township,	661	647
FRANKLIN COUNTY,	54,902	51,433
Antrim township,	4,556	4,359
Chambersburg borough,	8,894	7,963
First ward,	2,116	
Second ward,	2,367	
Third ward,	2,510	
Fourth ward,	1,671	
Fannett township,	2,253	2,330
Greencastle borough,	1,463	1,525
Greene township,	3,878	3,579
Guliford township,	3,785	3,754
Hamilton township,	1,851	1,659
Letterkenny township,	2,199	2,293
Lurgan township,	1,171	1,331
Metal township,	1,482	1,627
Montgomery township, including Mercersburg borough,	4,020	r 3,957
Mercersburg borough,	956	967
Peters township,	2,942	3,083
Quincy township,	3,033	2,972
St. Thomas township,	2,133	2,180
Southampton township, including Orrstown borough,	1,835	s 1,826
Orrstown borough,	245	252
Warren township,	550	566
Washington township,	3,481	2,732
Waynesboro borough,	5,396	3,811
First ward,	1,905	
Second ward,	1,301	
Third ward,	2,190	

(q) Organized from part of George township since 1890.

(t) Point Marion borough organized from part of Springhill township since 1890.

(o) Ohioville borough organized from part of Stewart township since 1890.

(r) Includes population of Mercersburg borough, given as independent in 1890.

(s) Includes population of Orrstown borough, given as independent in 1890.

TABLE II—Population of Pennsylvania by Minor Civil Divisions: 1890 and 1900—Continued.

Minor Civil Divisions.	1900.	1890.
FULTON COUNTY,	9,924	10,137
Ayr township,	1,310	1,331
Belfast township,	946	896
Bethel township,	844	1,012
Brush Creek township,	611	689
Dublin township,	899	941
Licking Creek township,	996	961
McConnellsburg borough,	576	594
Taylor township,	995	1,063
Thompson township,	813	796
Todd township,	685	582
Union township,	706	735
Wells township,	594	556
GREENE COUNTY,	28,281	28,935
Aleppo township,	1,348	1,537
Carmichaels borough,	456	445
Centre township,	1,775	1,787
Cumberland township,	1,734	1,739
Dunkard township,	1,310	1,366
Franklin township,	2,180	2,034
Gilmore township,	835	943
Greene township,	572	569
Greensboro borough,	399	427
Jackson township,	1,099	1,228
Jefferson borough,	311	337
Jefferson township,	976	928
Monongahela township,	742	814
Morgan township,	978	1,098
Morris township,	1,427	1,585
Mt. Morris borough (t),	345	.....
Perry township (t),	1,068	1,610
Richhill township,	2,766	2,900
Springhill township,	1,821	1,901
Washington township,	893	866
Wayne township,	1,824	1,757
Waynesburg borough,	2,544	2,101
North ward,	1,002	.....
South ward,	1,542	.....
Whiteley township,	398	1,068
HUNTINGDON COUNTY,	24,650	25,751
Alexandria borough,	406	438
Barree township,	521	601
Birmingham borough,	240	225
Brady township,	706	817
Broad Top City borough,	258	240
Carbon township,	1,377	1,311
Cass township,	544	590
Cassville borough,	168	185
Clay township,	820	904
Coalmont borough,	182	219
Cromwell township,	995	1,224
Dublin township,	996	967
Dudley borough,	290	281
Franklin township (u),	656	1,145
Henderson township,	615	630
Hopewell township,	570	611

(t) Mt. Morris borough organized from part of Perry township since 1890.

(u) Spruce Creek township organized from parts of Franklin and Morris townships since 1890.

TABLE II—Population of Pennsylvania by Minor Civil Divisions: 1890 and 1900—Continued.

Minor Civil Divisions.	1900.	1890
HUNTINGDON COUNTY—Continued.		
Huntingdon borough,	6,053	5,729
First ward,	922	
Second ward,	1,456	
Third ward,	1,571	
Fourth ward,	2,104	
Jackson township,	1,276	1,450
Junata township,	402	403
Lincoln township,	548	553
Logan township,	596	586
Mapleton borough,	612	715
Marklesburg borough,	260	279
Miller township,	311	345
Morris township (u),	419	726
Mt. Union borough,	1,086	810
Oxley township,	391	401
Orblsonia borough,	653	963
Penn township,	922	934
Petersburg borough,	781	555
Porter township,	839	906
Rock Hill borough,	495	657
Saltillo borough,	377	254
Shade Gap borough,	138	209
Shirley township,	1,221	1,522
Shirleysburg borough,	230	325
Smithfield township,	953	621
Springfield township,	735	810
Spruce Creek township (u),	789	
Tell township,	990	1,108
Three Springs borough,	196	193
Tod township,	703	753
Union township,	775	531
Walker township,	576	611
Warriorsmark township,	1,848	1,343
West township,	571	773
INDIANA COUNTY,	42,556	v 42,175
Armagh borough,	131	162
Armstrong township,	1,069	1,205
Banks township (w),	1,708	1,486
Blacklick township,	707	800
Blairsville borough,	2,386	3,126
First ward,	1,010	
Second ward,	1,057	
Third ward,	1,319	
Brushvalley township,	987	1,180
Buffington township,	653	652
Eurrell township,	1,435	1,414
Canoe township,	1,290	1,276
Centre township,	1,500	1,387
Cherryhill township,	1,648	1,967
Cherrytree borough,	312	324
Conemaugh township,	1,653	1,558
East Mahoning township,	835	1,030
East Wheatfield township,	859	786
Glen Campbell borough (x),	1,623	
Grant township,	1,285	1,350
Green township,	2,128	2,402
Homer City borough,	570	505

(u) Spruce Creek township organized from parts of Franklin and Morris townships since 1890.

(v) Includes population (1,634) of West Indiana borough, annexed to Indiana borough.

(w) Part taken to form Glen Campbell borough since 1890.

(x) Organized from part of Banks township since 1890.

TABLE II—Population of Pennsylvania by Minor Civil Divisions: 1890 and 1900—
Continued.

Minor Civil Divisions.	1900.	1890.
INDIANA COUNTY—Continued.		
Indiana borough (y),	4,142	1,963
First ward,	964	
Second ward,	806	
Third ward,	1,633	
Fourth ward,	739	
Jacksonville borough,	82	83
Marion Centre borough,	294	367
Mechanicsburg borough,	161	198
Montgomery township,	1,299	1,111
North Mahoning township,	1,122	1,255
Pine township,	911	1,005
Rayne township,	1,619	1,897
Saltsburg borough,	828	1,088
Shelocta borough,	92	82
Smicksburg borough,	237	229
South Mahoning township,	1,266	1,331
Washington township,	1,349	1,573
West Mahoning township,	948	1,056
West Wheatfield township,	1,873	1,771
White township,	1,400	1,635
Young township,	1,089	1,238
JEFFERSON COUNTY,		
	59,113	44,005
Barnett township,	460	360
Beaver township,	876	993
Bell township,	1,392	1,015
Big Run borough,	879	781
Brockwayville borough,	1,777	929
Brookville borough,	2,472	2,478
Clayville borough,	2,371	1,402
Clover township,	604	642
Corsica borough,	293	338
Eldred township,	1,535	1,581
Gaskill township,	713	682
Heath township,	325	236
Henderson township,	1,041	1,024
Knox township,	1,255	1,860
McCalmont township,	5,121	1,031
Oliver township,	1,455	1,362
Perry township,	1,545	1,228
Pinecreek township,	1,162	1,347
Polk township,	653	616
Porter township,	592	647
Punxsutawney borough,	4,375	2,792
Reynoldsville borough,	3,435	2,789
Ringgold township,	1,037	1,004
Rose township,	1,805	1,830
Snyder township,	2,117	2,011
Summerville borough,	380	338
Union township,	732	803
Warsaw township,	1,563	1,567
Washington township,	3,816	2,643
West Reynoldsville borough (x),	774	
Winslow township (x),	6,435	3,493
Worthville borough,	154	176
Young township,	5,969	4,557

(y) West Indiana borough annexed since 1890.

(x) West Reynoldsville borough organized from part of Winslow township since 1890.

TABLE II—Population of Pennsylvania by Minor Civil Divisions: 1890 and 1900—Continued.

Minor Civil Divisions.	1900.	1890.
JUNIATA COUNTY,	16,054	16,655
Beale township,	896	932
Delaware township,	1,133	1,144
Fayette township,	1,634	1,755
Fermanagh township,	860	963
Greenwood township,	563	569
Lack township,	1,208	1,221
Mifflintown borough,	953	877
Milford township,	1,204	1,276
Monroe township,	1,078	1,092
Patterson borough,	817	836
Port Royal borough,	546	519
Spruce Hill township,	782	935
Susquehanna township,	601	697
Thompsontown borough,	273	291
Turbett township,	683	693
Tuscarora township,	1,442	1,370
Walker township,	1,392	1,490
LACKAWANNA COUNTY,	193,321	142,083
Archbald borough,	5,396	4,033
First ward,	2,522	
Second ward,	1,607	
Third ward,	1,267	
Benton township,	1,024	1,053
Blakely borough,	3,915	2,452
First ward,	1,325	
Second ward,	1,518	
Third ward,	1,072	
Carbondale city,	13,536	10,333
First ward,	2,774	
Second ward,	1,706	
Third ward,	3,146	
Fourth ward,	2,253	
Fifth ward,	1,842	
Sixth ward,	1,817	
Carbondale township,	1,440	1,784
Clifton township,	200	172
Covington township,	794	894
Dalton borough (a),	681	
Dixon borough (b),	4,948	3,110
First ward,	1,463	
Second ward,	1,402	
Third ward,	2,083	
Dunmore borough,	12,583	8,315
First ward,	2,490	
Second ward,	2,781	
Third ward,	2,940	
Fourth ward,	444	
Fifth ward,	393	
Sixth ward,	3,535	
Elmhurst borough (c),	444	443
Fell township (d),	2,404	1,154
Glenburn borough,	307	290
Gouldsboro borough,	93	141
Greenfield township,	681	673
Jefferson township,	750	696

(a) Dalton borough and West Abington township organized from parts of North Abington township since 1890.

(b) Throop borough organized from part of Dickson borough since 1890.

(c) Formerly Dunning.

(d) Vandling borough organized from part of Fell township since 1890.

TABLE II—Population of Pennsylvania by Minor Civil Divisions: 1890 and 1900—Continued.

Minor Civil Divisions.	1900.	1890.
LACKAWANNA COUNTY—Continued.		
Jermyn borough,	2,567	2,650
First ward,	952	
Second ward,	886	
Third ward,	729	
Lackawanna township (e),	5,623	8,061
La Plume borough,	274	253
Lehigh township,	129	146
Madison township,	1,242	1,257
Mayfield borough (f),	2,300	1,695
Moosic borough (g),	1,227	
Newton township,	1,281	1,069
North Abington township (a),	362	1,090
Old Forge borough (h),	5,630	
Old Forge township (i),	45	4,422
Olyphant borough,	6,180	4,063
First ward,	1,082	
Second ward,	2,203	
Third ward,	1,270	
Fourth ward,	1,625	
Ransom township,	894	650
Roaring Brook township,	213	335
Scott township,	1,255	1,213
Scranton city,	102,026	75,215
First ward,	7,636	
Second ward,	8,168	
Third ward,	3,023	
Fourth ward,	7,300	
Fifth ward,	7,659	
Sixth ward,	4,140	
Seventh ward,	2,563	
Eighth ward,	2,630	
Ninth ward,	4,921	
Tenth ward,	3,364	
Eleventh ward,	5,420	
Twelfth ward,	2,568	
Thirteenth ward,	5,520	
Fourteenth ward,	3,754	
Fifteenth ward,	4,979	
Sixteenth ward,	3,617	
Seventeenth ward,	4,982	
Eighteenth ward,	2,071	
Nineteenth ward,	8,253	
Twentieth ward,	6,728	
Twenty-first ward,	2,730	
South Abington township,	1,612	1,063
Spring Brook township,	458	756
Taylor borough (k),	4,215	
First ward,	1,200	
Second ward,	669	
Third ward,	1,140	
Fourth ward,	613	
Fifth ward,	603	
Throop borough (b),	2,204	
Vandling borough (d),	765	

(e) Parts taken to form Moosic borough and part of Taylor borough since 1890.

(f) Formerly Mayville.

(g) Organized from part of Lackawanna township since 1890.

(h) Dalton borough and West Abington township organized from parts of North Abington township since 1890.

(i) Organized from part of Old Forge township since 1890.

(j) Parts taken to form Old Forge borough and part of Taylor borough since 1890.

(k) Organized from parts of Lackawanna and Old Forge townships since 1890.

(b) Throop borough organized from part of Dickson borough since 1890.

(d) Vandling borough organized from part of Fell township since 1890.

TABLE II—Population of Pennsylvania by Minor Civil Divisions: 1890 and 1900—Continued.

Minor Civil Divisions.	1900.	1890.
LACKAWANNA COUNTY—Continued.		
Waverly borough,	489	292
West Abington township (a),	219	.....
Winton borough,	3,425	1,797
LANCASTER COUNTY,	159,241	149,095
Adamstown borough,	597	603
Akron borough (l),	653	606
Bart township,	1,154	1,292
Brecknock township,	1,834	1,742
Caernarvon township,	1,466	1,580
Christiana (m),	828	.....
Clay township,	1,631	1,558
Colerain township,	1,559	1,588
Columbia borough,	12,316	10,599
First ward,	1,714	.....
Second ward,	1,170	.....
Third ward,	1,444	.....
Fourth ward,	1,645	.....
Fifth ward,	1,509	.....
Sixth ward,	1,326	.....
Seventh ward,	1,294	.....
Eighth ward,	1,009	.....
Ninth ward,	1,206	.....
Conestoga township,	1,787	2,195
Conoy township,	1,639	1,884
Drumore township,	1,358	1,484
Earl township (n),	2,327	2,618
East Coealico township,	3,921	2,674
East Donegal township,	3,275	3,384
East Drumore township (p),	1,270	1,502
East Earl township,	3,360	3,445
East Hempfield township,	3,168	3,154
East Lampeter township,	2,519	2,003
Eden township (p),	750	1,229
Elizabeth township,	937	1,012
Elizabethtown borough,	1,473	1,218
Ephrata borough (q),	2,451	.....
Ephrata township (r),	2,390	4,173
Fulton township,	1,674	1,828
Lancaster city,	41,459	32,011
First ward,	1,920	.....
Second ward,	3,673	.....
Third ward,	2,433	.....
Fourth ward,	3,382	.....
Fifth ward,	3,917	.....
Sixth ward,	6,526	.....
Seventh ward,	6,610	.....
Eighth ward,	7,553	.....
Ninth ward,	5,445	.....

(a) Dalton borough and West Abington township organized from parts of North Abington township since 1890.

(l) Formerly Akron village, in Ephrata township; incorporated as a borough in 1895.

(m) Christiana borough organized from part of Sadsbury township since 1890.

(n) New Holland village, formerly in Earl township, incorporated as a borough in 1895.

(o) Exclusive of population of New Holland village.

(p) Quarryville borough organized from parts of East Drumore and Eden townships since 1890.

(q) Organized from part of Ephrata township since 1890.

(r) Included Akron village (ncw borough) in 1890. Part taken to form Ephrata borough since 1890.

(s) Exclusive of population of Akron village.

TABLE II—Population of Pennsylvania by Minor Civil Divisions: 1890 and 1900—Continued.

Minor Civil Divisions.	1900.	1890.
LANCASTER COUNTY—Continued.		
Lancaster township,	1,782	1,177
Leacock township,	2,122	2,196
Littitz borough,	1,637	1,494
Little Britain township,	1,454	1,590
Manheim borough,	2,019	2,070
First ward,	697	
Second ward,	899	
Third ward,	423	
Manheim township,	3,111	2,883
Manor township,	4,766	4,960
Marletta borough,	2,469	2,402
First ward,	719	
Second ward,	890	
Third ward,	860	
Marticville township,	1,831	1,828
Mt. Joy borough,	2,018	1,848
Mt. Joy township,	2,252	2,258
New Holland borough (n),	902	1,060
Paradise township,	2,320	2,608
Penn township,	2,128	2,216
Pequea township,	1,261	1,299
Providence township,	1,680	1,856
Quarryville borough (p),	565	
Rapho township,	3,342	3,668
Sadsbury township (m),	1,023	1,861
Salisbury township,	3,548	3,751
Strasburg borough,	916	918
Strasburg township,	1,748	1,872
Upper Leacock township,	2,130	2,232
Warwick township,	3,501	3,153
Washington borough,	577	562
West Cocalico township,	2,255	2,238
West Donegal township,	1,341	1,295
West Earl township,	1,275	2,267
West Hempfield township,	3,602	3,704
West Lampeter township,	1,870	1,847
LAWRENCE COUNTY,		
	57,042	t 37,517
Big Beaver township,	1,488	1,647
Ellwood City borough (u),	2,243	
Enon Valley borough (v),	396	
Hickory township,	855	923
Little Beaver township (v),	735	1,193
Mahoning township,	2,617	2,079
Neshannock township,	1,080	1,171
Newcastle city (w),	28,339	11,600
First ward,	3,828	
Second ward,	3,012	
Third ward,	4,518	
Fourth ward,	4,193	
Fifth ward,	7,706	
Sixth ward,	2,629	
Seventh ward,	2,453	
New Wilmington borough,	791	684

(n) New Holland village, formerly in Earl township, incorporated as a borough in 1895.

(p) Quarryville borough organized from parts of East Drumore and Eden townships since 1890.

(m) Christiansa borough organized from part of Sadsbury township since 1890.

(t) Includes population (1,761) of West Newcastle borough, annexed to Newcastle city.

(u) Ellwood City borough organized from part of Wayne township since 1890.

(v) Enon Valley borough organized from part of Little Beaver township since 1890.

(w) Mahoningtown and West New Castle boroughs annexed since 1890.

TABLE II—Population of Pennsylvania by Minor Civil Divisions: 1890 and 1900—Continued.

Minor Civil Divisions.	1900.	1890.
LAWRENCE COUNTY—Continued.		
North Beaver township,	2,245	2,035
Perry township,	847	764
Plaingrove township,	655	723
Pulaski township,	1,607	1,609
Scott township,	845	907
Shenango township,	2,806	2,004
Slipperyrock township,	1,429	1,548
Taylor township (x),	571	1,374
Union township,	2,055	1,445
Volant borough (y),	120	.....
Wampum borough,	816	766
Washington township (y),	480	534
Wayne township (u),	3,109	1,787
Wilmington township,	915	1,008
LEBANON COUNTY,	53,827	48,131
Bethel township,	2,105	2,274
Cold Spring township,	29	18
Cornwall township (a),	1,539	2,487
East Hanover township,	1,889	1,550
Heidelberg township,	2,370	2,376
Jackson township,	3,820	3,830
Jonestown borough,	571	643
Lebanon city,	17,623	14,964
First ward,	3,125	.....
Second ward,	2,481	.....
Third ward,	1,550	.....
Fourth ward,	1,964	.....
Fifth ward,	4,812	.....
Sixth ward,	1,650	.....
Seventh ward,	2,056	.....
Millcreek township,	2,811	2,465
North Annville township,	2,578	2,008
North Cornwall township,	1,585	1,458
North Lebanon township,	4,960	3,723
North Londonderry township (b),	1,969	.....
South Annville township,	1,878	1,806
South Lebanon township,	2,882	2,557
South Londonderry township (b),	1,147	.....
Swatara township,	1,041	1,143
Union township,	1,599	1,699
West Cornwall township (a),	786	.....
West Lebanon township,	1,140	751
LEHIGH COUNTY,	93,593	76,631
Allentown city,	35,416	25,223
First ward,	3,705	.....
Second ward,	3,047	.....
Third ward,	3,385	.....
Fourth ward,	2,493	.....
Fifth ward,	2,348	.....

(x) Part taken to form Mahoningtown borough since 1890; borough subsequently annexed to Newcastle city.

(y) Volant borough organized from part of Washington township since 1890.

(u) Ellwood City borough organized from part of Wayne township since 1890.

(z) Includes population (2,673) of Londonderry township.

(a) West Cornwall township organized from part of Cornwall township since 1890.

(b) North and South Londonderry townships organized from Londonderry township since 1890.

TABLE II—Population of Pennsylvania by Minor Civil Divisions: 1890 and 1900—Continued.

Minor Civil Divisions.	1900.	1890.
LEHIGH COUNTY—Continued.		
Allentown city—Continued.		
Sixth ward,	3,658	
Seventh ward,	3,623	
Eighth ward,	4,137	
Ninth ward,	2,686	
Tenth ward,	3,343	
Eleventh ward,	1,986	
Catasauqua borough,	2,963	3,704
First ward,	1,854	
Second ward,	2,109	
Coopersburg borough,	556	454
Coplay borough,	1,581	880
Emaus borough,	1,468	882
Fountain Hill borough (c),	1,214	
Hanover township,	3,324	2,868
Heidelberg township,	1,411	1,487
Lower Macungie township,	2,920	3,657
Lower Milford township,	1,233	1,424
Lowhill township,	715	763
Lynn township,	2,366	2,635
Macungie borough,	692	644
North Whitehall township,	3,280	2,847
Salisbury township (c),	4,538	4,100
Slatington borough,	3,773	2,716
South Whitehall township,	2,472	2,304
Upper Macungie township,	2,061	2,511
Upper Milford township,	2,712	2,394
Upper Saucon township,	2,371	2,832
Washington township,	3,096	2,668
Weisenberg township,	1,366	1,514
West Bethlehem borough,	2,465	2,759
First ward,	1,394	
Second ward,	1,880	
Third ward,	691	
Whitehall township,	7,935	5,514
LUZERNE COUNTY,	257,121	261,203
Ashley borough,	4,046	3,192
First ward,	1,623	
Second ward,	1,136	
Third ward,	1,287	
Avoca borough,	2,487	3,061
First ward,	1,073	
Second ward,	1,216	
Third ward,	1,198	
Bear Creek township,	240	343
Black Creek township,	2,352	2,178
Buck township,	108	94
Butler township,	1,651	1,984
Conyngham township,	1,373	1,299
Court Dale borough (d),	420	
Dallas borough,	543	415
Dallas township,	1,006	885
Denison township,	796	972
Dorrance borough,	2,211	586
Dorrance township,	830	742
Edwardsville borough,	5,165	3,284
First ward,	1,091	
Second ward,	946	

(c) Fountain Hill borough organized from part of Salisbury township since 1890.

(d) Court Dale and Swoyersville boroughs organized from parts of Kingston township since 1890.

TABLE II—Population of Pennsylvania by Minor Civil Divisions: 1890 and 1900—Continued.

Minor Civil Divisions.	1900.	1890.
LUZERNE COUNTY—Continued.		
Edwardsville borough—Continued.		
Third ward,	723	
Fourth ward,	1,310	
Fifth ward,	657	
Sixth ward,	438	
Exeter borough,	1,948	790
First ward,	299	
Second ward,	1,649	
Exeter township,	504	452
Fairmount township,	1,070	1,090
Fairview township,	1,087	1,008
Forty Fort borough,	1,557	1,031
First ward,	610	
Second ward,	584	
Third ward,	363	
Foster township,	4,497	7,590
Franklin township,	501	531
Freeland borough,	5,254	1,730
South ward,	2,039	
First ward,	826	
Second ward,	830	
Third ward,	560	
Fourth ward,	999	
Hanover township,	4,655	2,579
Hazel township,	15,143	12,494
Hazleton city (e),	14,230	11,972
First ward,	1,377	
Second ward,	1,199	
Third ward,	1,909	
Fourth ward,	1,616	
Fifth ward,	973	
Sixth ward,	552	
Seventh ward,	927	
Eighth ward,	1,322	
Ninth ward,	1,869	
Tenth ward,	1,401	
Eleventh ward,	1,085	
Hollenback township,	654	724
Hughestown borough,	1,548	1,454
Hunlock township,	837	881
Huntingdon township,	1,428	1,557
Jackson township,	658	657
Jeddo borough,	1,632	358
Jenkins township,	2,792	2,320
Kingston borough,	3,846	2,331
First ward,	814	
Second ward,	996	
Third ward,	927	
Fourth ward,	1,109	
Kingston township (d),	2,061	3,808
Lafin borough,	254	231
Lake township,	1,397	1,144
Laurel Run borough,	696	606
Lehman township,	1,120	1,093
Luzerne borough,	3,817	2,398
First ward,	1,142	
Second ward,	973	
Third ward,	918	
Fourth ward,	785	
Marcy township,	5,541	2,904
Miners Mills borough,	2,244	2,075
First ward,	1,124	
Second ward,	1,100	

(e) Incorporated as city since 1890.

(d) Courtdale and Swoyersville boroughs organized from parts of Kingston township since 1890.

TABLE II—Population of Pennsylvania by Minor Civil Divisions: 1890 and 1900—Continued.

Minor Civil Divisions.	1900.	1890.
LUZERNE COUNTY—Continued.		
Nanticoke borough,	12,118	10,044
First ward,	865	
Second ward,	906	
Third ward,	430	
Fourth ward,	964	
Fifth ward,	1,336	
Sixth ward,	945	
Seventh ward,	847	
Eighth ward,	768	
Ninth ward,	2,079	
Tenth ward,	1,027	
Eleventh ward,	1,949	
Nescopeck borough (f),	1,100	698
Nescopeck township (f),	702	8 758
New Columbus borough,	202	214
Newport township,	6,529	5,411
Parsons borough,	2,529	2,412
Pittston city (h),	12,556	10,302
First ward,	1,011	
Second ward,	626	
Third ward,	1,181	
Fourth ward,	1,166	
Fifth ward,	1,254	
Sixth ward,	1,761	
Seventh ward,	935	
Eighth ward,	506	
Ninth ward,	826	
Tenth ward,	1,640	
Eleventh ward,	1,650	
Pittston township (i),	4,370	3,284
Plains township,	6,572	6,576
Plymouth borough,	12,649	9,244
First ward,	1,353	
Second ward,	1,169	
Third ward,	1,122	
Fourth ward,	908	
Fifth ward,	951	
Sixth ward,	1,613	
Seventh ward,	888	
Eighth ward,	922	
Ninth ward,	1,145	
Tenth ward,	596	
Eleventh ward,	912	
Twelfth ward,	920	
Thirteenth ward,	640	
Plymouth township,	9,655	8,363
Ross township,	1,386	1,102
Salem township,	1,317	1,306
Shickshinny borough,	1,456	1,448
Slocum township,	543	409
Sugarloaf township,	1,500	1,854
Sugarnotch borough (k),	1,887	2,536
Swoyersville borough (d),	2,264	
Union township,	919	874
Warrior Run borough (k),	965	
West Hazleton borough,	2,516	931

(f) Nescopeck town, formerly in Nescopeck township, incorporated as a borough since 1890.

(g) Exclusive of population of Nescopeck town.

(h) Incorporated as a city, and part of Pittston township annexed since 1890.

(i) Part annexed to Pittston city since 1890.

(k) Warrior Run borough organized from part of Sugarnotch borough since 1890.

(d) Courtdale and Swoyersville boroughs organized from parts of Kingston township since 1890.

TABLE II—Population of Pennsylvania by Minor Civil Divisions: 1890 and 1900—Continued.

Minor Civil Divisions.	1900.	1890.
LUZERNE COUNTY—Continued.		
West Hazleton borough—Continued.		
First ward,	952	
Second ward,	667	
Third ward,	897	
West Pittston borough,	5,846	3,908
West Wyoming borough (1),	1,344	
Whitehaven borough,	1,517	1,634
First ward,	800	
Second ward,	717	
Wilkes-Barre city,	51,721	37,713
First ward,	2,983	
Second ward,	3,685	
Third ward,	4,202	
Fourth ward,	1,604	
Fifth ward,	1,863	
Sixth ward,	2,981	
Seventh ward,	1,022	
Eighth ward,	2,016	
Ninth ward,	2,849	
Tenth ward,	2,323	
Eleventh ward,	2,535	
Twelfth ward,	2,864	
Thirteenth ward,	6,260	
Fourteenth ward,	6,620	
Fifteenth ward,	3,194	
Sixteenth ward,	4,709	
Wilkes-Barre township,	3,806	2,917
Wright township,	329	152
Wyoming borough (1),	1,909	1,794
First ward,	783	
Second ward,	688	
Third ward,	438	
Yates borough,	433	414
LYCOMING COUNTY,		
	76,663	70,579
Anthony township,	484	562
Armstrong township,	328	385
Bastress township,	229	236
Brady township,	464	475
Brown township,	891	835
Cascade township,	615	609
Clinton township,	1,263	1,326
Cogan House township,	1,142	1,126
Cummings township,	474	422
Dubolstown borough,	650	697
Eldred township,	633	656
Fairfield township,	442	463
Franklin township,	1,110	1,063
Gamble township,	661	754
Hepburn township,	797	769
Hughesville borough,	1,528	1,358
First ward,	778	
Second ward,	750	
Jackson township,	531	619
Jersey Shore borough,	3,070	1,863
First ward,	1,240	
Second ward,	883	
Third ward,	947	
Jordan township,	878	891
Lewis township,	839	985

(1) West Wyoming borough organized from part of Wyoming borough since 1890.

TABLE II—Population of Pennsylvania by Minor Civil Divisions: 1890 and 1900—Continued.

Minor Civil Divisions.	1900.	1890.
LYCOMING COUNTY—Continued.		
Limestone township,	1,118	1,096
Loyalsock township,	3,468	2,498
Lycoming township,	578	643
McHenry township,	1,086	908
McIntyre township,	1,700	845
McNett township,	508	619
Miffin township,	618	695
Mill Creek township,	310	345
Montgomery borough,	1,063	777
Montoursville borough,	1,665	1,378
First ward,	816	
Second ward,	849	
Moreland township,	712	737
Muncy borough,	1,934	1,296
First ward,	574	
Second ward,	549	
Third ward,	811	
Muncy township,	784	701
Muncy Creek township,	1,381	1,740
Nippenose township,	516	588
Old Lycoming township,	575	539
Penn township,	838	877
Platt township,	447	521
Picture Rocks borough,	614	510
Pine township,	965	901
Plunketts Creek township,	565	777
Porter township,	680	1,007
Salladasburg borough,	261	374
Shrewsbury township,	617	570
South Williamsport borough,	3,328	2,900
First ward,	988	
Second ward,	1,232	
Third ward,	1,068	
Susquehanna township,	292	294
Upper Fairfield township,	731	771
Washington township,	961	937
Watson township,	266	264
Williamsport city,	23,757	27,133
First ward,	1,762	
Second ward,	1,769	
Third ward,	2,799	
Fourth ward,	1,794	
Fifth ward,	3,676	
Sixth ward,	2,702	
Seventh ward,	1,909	
Eighth ward,	3,135	
Ninth ward,	2,014	
Tenth ward,	1,853	
Eleventh ward,	1,406	
Twelfth ward,	2,324	
Thirteenth ward,	1,613	
Wolf township,	638	734
Woodward township,	794	817
McKEAN COUNTY,	51,843	m 46,863
Annin township,	914	1,138
Bradford city (n),	15,029	10,514
First ward,	1,810	
Second ward,	3,089	

(m) Includes population (1,937) of Kendall borough.

(n) Kendall borough annexed since 1890.

TABLE II—Population of Pennsylvania by Minor Civil Divisions: 1890 and 1900—Continued.

Minor Civil Divisions.	1900.	1890.
McKEAN COUNTY—Continued.		
Bradford city—Continued.		
Third ward,	2,987	
Fourth ward,	2,907	
Fifth ward,	2,249	
Sixth ward,	1,987	
Bradford township,	2,933	3,246
Ceres township,	1,106	1,307
Corydon township,	260	337
Eldred borough,	968	1,060
Eldred township,	1,493	1,533
Foster township,	1,793	3,107
Hamilton township,	1,596	1,734
Hamlin township,	3,484	1,722
Kane borough,	5,296	2,944
First ward,	986	
Second ward,	1,793	
Third ward,	1,118	
Fourth ward,	1,399	
Keating township,	2,845	2,577
Lafayette township,	1,690	1,913
Liberty township,	1,694	2,174
Mt. Jewett borough (o),	1,553	.....
Norwich township,	978	1,109
Otto township,	1,643	2,429
Port Allegany borough,	1,863	1,230
Sergeant township,	1,057	948
Smethport borough,	1,704	1,150
Wetmore township,	1,454	1,359
MERCER COUNTY,	57,387	p 55,744
Bethel borough,	107	81
Clarksville borough,	220	(p)
Coolspring township,	983	859
Deer Creek township,	476	519
Delaware township,	1,333	1,480
East Lackawannock township,	649	656
Fairview township,	715	783
Findley township,	1,123	1,393
Fredonia borough,	437	429
French Creek township,	772	903
Greene township,	680	763
Greenville borough,	4,814	3,674
First ward,	1,416	
Second ward,	1,534	
Third ward,	1,564	
Grove City borough,	1,599	1,160
Hempfield township,	858	961
Hickory township,	4,965	3,639
Jackson township,	984	1,226
Jackson Centre borough,	276	323
Jamestown borough,	834	822
Jefferson township,	923	982
Lackawannock township,	751	937
South ward,	934	
Lake township,	681	885
North ward,	870	
Liberty township,	537	607
Mercer borough,	1,804	2,138

(o) Mt. Jewett borough organized from part of Hamlin township since 1890.

(p) Clarksville borough and Pymatuning township (population 2,095) not separately returned in 1890.

TABLE II—Population of Pennsylvania by Minor Civil Divisions: 1890 and 1900—Continued.

Minor Civil Divisions.	1900.	1890.
MERCER COUNTY—Continued.		
Mill Creek township,	714	821
New Lebanon borough,	185	263
New Vernon township,	643	720
Otter Creek township,	428	483
Perry township,	976	1,125
Pine township,	2,139	1,909
Pymatuning township,	1,828	(p)
Salem township,	499	540
Sandy Creek township,	617	674
Sandy Lake borough,	632	721
Sandy Lake township,	1,012	1,118
Sharon borough,	8,916	7,459
First ward,	1,809	
Second ward,	1,244	
Third ward,	1,971	
Fourth ward,	1,661	
Fifth ward,	1,511	
Sixth ward,	720	
Sharpville borough,	2,970	2,330
First ward,	915	
Second ward,	1,039	
Third ward,	1,016	
Sheakleyville borough,	164	191
Shenango township,	1,155	1,140
Springfield township,	1,225	1,368
Stoneboro borough,	1,061	1,394
Sugar Grove township,	671	664
West Middlesex borough,	930	966
West Salem township,	1,338	2,043
Wheatland borough,	655	575
Wilmington township,	414	508
Wolf Creek township,	510	542
Worth township,	930	987
MIFFLIN COUNTY,	23,160	19,996
Armagh township,	2,435	2,097
Bratton township,	979	1,144
Brown township,	1,678	1,467
Decatur township,	1,420	1,458
Derry township (q),	4,749	3,283
Granville township,	1,734	1,472
Lewistown borough,	4,451	3,273
East ward,	2,067	
South ward,	541	
West ward,	1,823	
McVeytown borough,	520	599
Menno township,	1,007	1,021
Newton Hamilton borough,	384	333
Oliver township,	1,119	1,099
Union township,	1,418	1,381
Wayne township,	1,266	1,379
MONROE COUNTY,	21,161	20,111
Barrett township,	845	947
Chestnuthill township,	1,398	1,469

(p) Clarksville borough and Pymatuning township (population 2,095) not separately returned in 1890.

(q) Given as North and South Derry in 1890.

TABLE II—Population of Pennsylvania by Minor Civil Divisions: 1890 and 1900—Continued.

Minor Civil Divisions.	1900.	1890.
MONROE COUNTY—Continued.		
Coolbaugh township,	1,062	1,206
Delaware Watergap borough,	469	467
East Stroudsburg borough,	2,648	1,819
Eldred township,	961	907
Hamilton township,	1,462	1,626
Jackson township,	711	741
Middle Smithfield township,	1,067	1,122
Paradise township,	727	672
Pocono township,	1,062	1,041
Polk township,	1,027	1,126
Price township,	202	181
Ross township,	682	727
Smithfield township,	1,103	1,099
Stroud township,	1,322	1,566
Stroudsburg borough,	2,450	2,419
Tobyhanna township,	654	620
Tunkhannock township,	329	348
MONTGOMERY COUNTY,	128,996	r 122,290
Abington township (s),	2,803	2,708
Ambler borough,	1,884	1,072
First ward,	700	
Second ward,	1,184	
Bridgeport borough,	3,097	2,051
First ward,	1,080	
Second ward,	962	
Third ward,	1,115	
Cheltenham township,	6,154	4,746
Collegeville borough (t),	611	
Conshohocken borough,	5,762	5,470
First ward,	1,176	
Second ward,	1,048	
Third ward,	1,404	
Fourth ward,	299	
Fifth ward,	1,196	
Douglass township,	1,650	1,067
East Greenville borough,	894	529
Franconia township (u),	2,036	2,258
Frederick township,	1,690	1,850
Greenlane borough,	272	227
Hatboro borough,	823	781
Hatfield borough (v),	528	
Hatfield township (v),	1,497	1,313
Horsham township,	1,167	1,229
Jenkintown borough,	2,091	1,609
First ward,	961	
Second ward,	1,140	
Lansdale borough,	2,754	1,353
East ward,	1,564	
West ward,	1,190	
Limerick township,	2,260	2,224
Lower Gwynedd township (w),	1,196	

(r) Includes population (4,262) of Gwynedd and Pottsgrove townships; Gwynedd taken to form Lower and Upper Gwynedd townships.

(s) Rockledge borough organized from part of Albright township since 1890.

(t) Collegeville and Trappe boroughs organized from parts of Upper Providence township since 1890.

(u) West Telford borough organized from part of Franconia township since 1890.

(v) Hatfield borough organized from part of Hatfield township since 1890.

(w) Lower and Upper Gwynedd townships organized from Gwynedd township (population 2,267) in 1890.

TABLE II—Population of Pennsylvania by Minor Civil Divisions: 1890 and 1900—Continued.

Minor Civil Divisions.	1900.	1890.
MONTGOMERY COUNTY—Continued.		
Lower Merion township (x),	13,271	10,362
Lower Pottsgrove township (y),	665	.....
Lower Providence township,	1,625	1,374
Lower Salford township,	1,763	1,755
Marlboro township,	1,129	1,151
Montgomery township,	724	536
Moreland township,	2,462	1,889
Narberth borough (x),	847	.....
New Hanover township,	1,611	1,728
Norristown borough,	22,285	19,791
First ward,	2,239	.....
Second ward,	2,127	.....
Third ward,	1,679	.....
Fourth ward,	2,415	.....
Fifth ward,	2,334	.....
Sixth ward,	4,105	.....
Seventh ward,	2,210	.....
Eighth ward,	1,236	.....
Ninth ward,	1,540	.....
Tenth ward,	2,320	.....
Norriton township,	1,177	1,236
North Wales borough,	1,287	1,060
Pennsburg borough,	1,032	627
Perkiomen township,	1,062	1,024
Plymouth township,	1,949	2,244
Pottstown borough,	13,696	13,285
West ward,	1,395	.....
Second ward,	1,421	.....
Third ward,	1,234	.....
Fourth ward,	1,054	.....
Fifth ward,	1,539	.....
Sixth ward,	1,265	.....
Seventh ward,	1,007	.....
Eighth ward,	1,507	.....
Ninth ward,	1,967	.....
Tenth ward,	1,307	.....
Rockledge borough (s),	512	.....
Royersford borough,	2,607	1,815
First ward,	439	.....
Second ward,	1,242	.....
Third ward,	442	.....
Fourth ward,	484	.....
Salford township (z),	789	.....
Skippack township,	1,248	1,380
Souderton borough,	1,077	679
Springfield township,	2,400	1,832
Towamensing township,	1,085	1,140
Trappe borough (t),	324	.....
Upper Dublin township,	1,933	2,008
Upper Gwynedd township (w),	1,328	.....
Upper Hanover township,	1,987	1,977
Upper Merion township,	3,480	3,405
Upper Pottsgrove township (y),	1,341	.....
Upper Providence township (t),	2,574	3,529

(x) Narberth borough organized from part of Lower Merion township since 1890.

(y) Lower and Upper Pottsgrove townships given as Pottsgrove township (population 1,885) in 1890.

(s) Rockledge borough organized from part of Abington township since 1890.

(z) Salford township organized from part of Upper Salford township since 1890.

(t) Collegeville and Trappe boroughs organized from parts of Upper Providence township since 1890.

(w) Lower and Upper Gwynedd townships organized from Gwynedd township (population 2,367) in 1890.

TABLE II—Population of Pennsylvania by Minor Civil Divisions: 1890 and 1900—Continued.

Minor Civil Divisions.	1900.	1890.
MONTGOMERY COUNTY—Continued.		
Upper Salford township (s),	876	1,869
West Conshohocken borough,	1,958	1,666
West Telford borough (u),	534	.....
Whitemarsh township,	3,350	3,516
Whitepain township,	1,442	1,565
Worcester township,	1,397	1,517
MONTOUR COUNTY,	15,536	15,645
Anthony township,	906	962
Cooper township,	339	334
Danville borough,	8,042	7,995
First ward,	2,126	.....
Second ward,	1,433	.....
Third ward,	2,551	.....
Fourth ward,	1,933	.....
Derry township,	690	772
Liberty township,	969	1,061
Limestone township,	620	678
Mahoning township,	2,319	2,171
Mayberry township,	242	198
Valley township,	831	890
Washingtonville borough,	212	171
West Hemlock township,	347	390
NORTHAMPTON COUNTY,	99,687	a 84,220
Allen township,	6,541	3,474
Bangor borough,	4,106	2,509
First ward,	1,223	.....
Second ward,	833	.....
Third ward,	1,090	.....
Fourth ward,	950	.....
Bath borough,	781	723
Bethlehem borough,	7,293	6,752
First ward,	1,594	.....
Second ward,	2,017	.....
Third ward,	1,740	.....
Fourth ward,	1,942	.....
Bethlehem township,	3,090	2,397
Bushkill township,	1,586	1,644
Chapman borough,	319	392
East Allen township,	1,137	1,104
East Bangor borough,	983	804
Easton city (b),	25,238	14,481
First ward,	1,596	.....
Second ward,	1,988	.....
Third ward,	2,620	.....
Fourth ward,	2,759	.....
Fifth ward,	1,769	.....
Sixth ward,	2,771	.....
Seventh ward,	1,902	.....
Eighth ward,	2,976	.....
Ninth ward,	907	.....
Tenth ward,	2,394	.....
Eleventh ward,	2,128	.....
Twelfth ward,	1,429	.....

(z) Salford township organized from part of Upper Salford township since 1890.

(u) West Telford borough organized from part of Franconia township since 1890.

(a) Includes population (5,616) of South Easton borough.

(b) South Easton borough annexed since 1890.

TABLE II—Population of Pennsylvania by Minor Civil Divisions: 1890 and 1900—Continued.

Minor Civil Divisions.	1900.	1890.
NORTHAMPTON COUNTY—Continued.		
Forks township,	1,147	1,189
Freemansburg borough,	596	616
Glendon borough,	704	907
Hanover township,	401	440
Hellertown borough,	745	708
Lehigh township,	3,769	3,570
Lower Mt. Bethel township,	1,335	1,322
Lower Nazareth township,	1,034	930
Lower Saucon township,	4,141	3,913
Moore township,	2,293	2,544
Nazareth borough,	2,304	1,318
Palmer township (c),	2,051	2,396
Pen Argyl borough,	2,784	2,106
First ward,	996	
Second ward,	736	
Third ward,	1,052	
Plainfield township (d),	2,042	2,521
Portland borough,	490	676
South Bethlehem borough,	13,241	10,302
First ward,	2,578	
Second ward,	2,853	
Third ward,	2,765	
Fourth ward,	3,131	
Fifth ward,	1,909	
Tatamy borough (e),	260	
Upper Mt. Bethel township,	2,446	3,106
Upper Nazareth township,	736	550
Washington township,	2,614	2,523
West Easton borough (e),	1,000	
Williams township,	1,819	2,676
Wind Gap borough (f),	711	
NORTHUMBERLAND COUNTY,		
	90,911	87,468
Coal township,	12,473	8,616
Delaware township,	1,581	1,864
East Cameron township (h),	865	
East Chillisquaque township (i),	492	
Gearhart township (k),	479	
Jackson township,	1,277	1,046
Jordan township,	886	914
Lewis township,	1,030	1,151
Little Mahanoy township,	284	327
Lower Augusta township,	697	839
Lower Mahanoy township,	1,653	1,750
McEwensville borough,	208	262
Milton borough,	6,175	5,317
First ward,	868	
Second ward,	1,000	
Third ward,	1,681	
Fourth ward,	1,296	
Fifth ward,	1,330	

(c) Parts taken to form Tatamy and West Easton boroughs since 1890.

(d) Part taken to form Wind Gap borough since 1890.

(e) Organized from parts of Palmer township since 1890.

(f) Organized from part of Plainfield township since 1890.

(g) Includes population (2,641) of Cameron and Chillisquaque townships.

(h) East and West Cameron townships organized from Cameron township (population 1,034 in 1890) since 1890.

(i) East and West Chillisquaque townships organized from Chillisquaque township (population 1,607 in 1890) since 1890.

(k) Gearhart township organized from part of Rush township since 1890.

TABLE II—Population of Pennsylvania by Minor Civil Divisions: 1890 and 1900—Continued.

Minor Civil Divisions.	1900.	1890.
NORTHUMBERLAND COUNTY—Continued.		
Mt. Carmel borough,	13,179	8,254
First ward,	2,421	
Second ward,	3,409	
Third ward,	3,544	
Fourth ward,	3,805	
Mt. Carmel township,	4,321	3,192
Northumberland borough,	2,748	2,714
First ward,	922	
Second ward,	1,087	
Third ward,	739	
Point township,	703	778
Ralpho township,	1,104	1,001
Riverside borough,	418	594
Rockefeller township,	1,053	1,071
Rush township, (k)	822	1,346
Shamokin borough,	18,202	14,463
First ward,	1,139	
Second ward,	2,571	
Third ward,	1,259	
Fourth ward,	2,714	
Fifth ward,	3,591	
Sixth ward,	2,174	
Seventh ward,	1,381	
Eighth ward,	794	
Ninth ward,	1,108	
Tenth ward,	1,071	
Shamokin township,	1,406	1,443
Snydertown borough,	276	242
Sunbury borough (l),	9,810	5,320
First ward,	1,016	
Second ward,	1,434	
Third ward,	1,823	
Fourth ward,	1,017	
Fifth ward,	1,106	
Sixth ward,	530	
Seventh ward,	1,249	
Eighth ward,	966	
Ninth ward,	670	
Turbut township,	757	732
Turbutville borough,	390	441
Upper Augusta township (m),	803	2,749
Upper Mahanoy township,	891	891
Washington township,	775	788
Watsontown borough,	1,898	2,157
First ward,	866	
Second ward,	1,032	
West Cameron township (h),	373	
West Chillisquaque township (i),	1,076	
Zerbe township,	1,746	1,355
PERRY COUNTY,	26,263	26,276
Blain borough,	326	249
Bloomfield borough,	772	737
Buffalo township,	576	691

(k) Gearhart township organized from part of Rush township since 1890.

(l) East Sunbury borough annexed since 1890.

(m) Part taken to form East Sunbury borough in 1890; borough subsequently annexed to Sunbury borough.

(h) East and West Cameron townships organized from Cameron township (population 1,034 in 1890) since 1890.

(i) East and West Chillisquaque townships organized from Chillisquaque township (population 1,607 in 1890) since 1890.

TABLE II—Population of Pennsylvania by Minor Civil Divisions: 1890 and 1900--
Continued.

Minor Civil Divisions.	1900.	1890.
PERRY COUNTY—Continued.		
Carroll township,	1,213	1,283
Center township,	1,046	1,046
Duncannon borough,	1,661	1,074
Greenwood township,	302	368
Howe township,	338	383
Jackson township,	981	955
Junata township,	878	928
Landisburg borough,	300	318
Liverpool borough,	653	821
Liverpool township,	678	751
Madison township,	1,568	1,584
Marysville borough,	1,463	1,115
Miller township,	586	356
Millerstown borough,	555	594
New Buffalo borough,	171	220
Newport borough,	1,734	1,417
Oliver township,	955	969
Penn township,	1,386	1,965
Rye township,	680	710
Saville township,	1,496	1,542
Spring township,	1,280	1,340
Toboyne township,	852	851
Tuscarora township,	747	762
Tyrone township,	1,447	1,562
Watts township,	407	396
Wheatfield township,	712	779
PHILADELPHIA COUNTY,		
Philadelphia city, coextensive with Philadelphia county,	1,293,697	1,046,964
First ward,	37,919	
Second ward,	35,206	
Third ward,	24,693	
Fourth ward,	22,562	
Fifth ward,	16,868	
Sixth ward,	8,042	
Seventh ward,	28,137	
Eighth ward,	15,757	
Ninth ward,	6,953	
Tenth ward,	19,967	
Eleventh ward,	11,843	
Twelfth ward,	12,350	
Thirteenth ward,	17,427	
Fourteenth ward,	19,405	
Fifteenth ward,	50,379	
Sixteenth ward,	15,788	
Seventeenth ward,	17,908	
Eighteenth ward,	23,643	
Nineteenth ward,	55,246	
Twentieth ward,	43,276	
Twenty-first ward,	32,168	
Twenty-second ward,	64,655	
Twenty-third ward,	26,109	
Twenty-fourth ward,	53,200	
Twenty-fifth ward,	51,753	
Twenty-sixth ward,	45,615	
Twenty-seventh ward,	32,204	
Twenty-eighth ward,	43,931	
Twenty-ninth ward,	60,096	
Thirtieth ward,	28,874	
Thirty-first ward,	33,139	
Thirty-second ward,	39,889	
Thirty-third ward,	65,372	
Thirty-fourth ward,	43,706	

TABLE II—Population of Pennsylvania by Minor Civil Divisions: 1890 and 1900—Continued.

Minor Civil Divisions.	1900.	1890.
PHILADELPHIA COUNTY—Continued.		
Philadelphia City—Continued.		
Thirty-fifth ward,	8,614	
Thirty-sixth ward,	46,811	
Thirty-seventh ward,	22,445	
Thirty-eighth ward,	33,104	
Thirty-ninth ward,	40,377	
Fortieth ward,	19,438	
Forty-first ward,	11,328	
PIKE COUNTY,	8,766	9,412
Blooming Grove township,	446	351
Delaware township,	721	799
Dingman township,	481	491
Greene township,	1,022	1,114
Lackawaxen township,	1,259	1,547
Lehman township,	658	742
Millford borough,	384	793
Millford township,	172	158
Palmyra township,	638	810
Porter township,	53	89
Shohola township,	701	960
Westfall township,	1,731	1,553
POTTER COUNTY,	30,621	22,773
Abbott township,	737	823
Allegany township,	928	636
Austin borough,	2,300	1,679
Bingham township,	911	877
Clara township,	414	290
Coudersport borough,	3,217	1,530
First ward,	1,614	
Second ward,	1,603	
Eulalia township,	1,315	1,268
Galeton borough (n),	2,415	
Genesee township,	1,179	910
Harrison township,	1,826	1,784
Hebron township,	915	876
Hector township,	1,124	1,180
Homer township,	209	891
Keating township,	784	382
Lewisville borough,	619	450
Oswayo township,	1,584	1,131
Pike township (o),	537	1,111
Pleasant Valley township,	276	241
Portage township,	1,088	314
Roulette township,	1,127	1,135
Sharon township,	1,443	1,164
Stewardson township,	1,299	483
Summit township,	523	176
Sweden township,	612	756
Sylvania township,	577	713
Ulysses township,	891	801
West Branch township,	1,022	675
Wharton township,	844	393

(n) Organized from part of Pike township since 1890.

(o) Part taken to form Galeton borough since 1890.

TABLE II—Population of Pennsylvania by Minor Civil Divisions: 1890 and 1900—Continued.

Minor Civil Divisions.	1900.	1890.
SCHUYLKILL COUNTY,	173,927	154,163
Ashland borough,	6,488	7,346
First ward,	1,300	
Second ward,	1,085	
Third ward,	1,328	
Fourth ward,	1,477	
Fifth ward,	1,068	
Auburn borough,	845	880
Barry township,	1,060	913
Blythe township,	1,749	1,320
Branch township,	1,250	961
Butler township (p),	3,693	q 4,493
Cass township,	3,538	2,642
Cressona borough,	1,738	1,481
North ward,	889	
South ward,	849	
Delano township (r),	1,278	1,362
East Brunswick township,	1,296	1,462
East Norwegian township,	588	586
East Union township,	2,553	1,116
Eldred township,	1,168	1,147
Poster township,	636	491
Frackville borough,	2,594	2,520
Fralley township,	993	1,321
Gilberton borough,	4,372	3,687
East ward,	2,039	
Middle ward,	840	
West ward,	1,494	
Girardville borough,	3,666	3,584
East ward,	1,314	
Middle ward,	1,900	
West ward,	752	
Gordon borough (p),	1,166	1,194
Hegins township,	2,177	1,896
Hubley township,	982	968
Kline township (s),	3,692	3,068
Landingville borough,	244	316
McAdoo borough (s),	2,122	
Mahanoy township,	6,214	6,541
Mahanoy City borough,	13,504	11,286
First ward,	4,671	
Second ward,	1,877	
Third ward,	1,257	
Fourth ward,	1,497	
Fifth ward,	4,202	
Middleport borough,	540	381
Minersville borough,	4,815	3,504
First ward,	1,563	
Second ward,	1,029	
Third ward,	1,139	
Fourth ward,	1,064	
Mt. Carbon borough,	262	333
Newcastle township,	1,300	1,317
New Philadelphia borough, ..	1,326	568
New Ringgold borough,	228	240
North Mannheim township,	2,163	2,391
North Union township,	1,243	1,124
Norwegian township,	770	819
Orwigsburg borough,	1,518	1,290

(p) Gordon village, formerly in Butler township, incorporated as a borough since 1890.

(q) Exclusive of population of Gordon village.

(r) Erroneously returned as Delano borough in 1890.

(s) McAdoo borough organized from part of Kline township since 1890.

TABLE II—Population of Pennsylvania by Minor Civil Divisions: 1890 and 1900—Continued.

Minor Civil Divisions.	1900.	1890.
SCHUYLKILL COUNTY—Continued.		
Palo Alto borough,	1,707	1,424
Pinegrove borough,	1,064	1,103
Pinegrove township,	2,534	2,601
Port Carbon borough,	2,168	1,976
Port Clinton borough,	478	606
Porter township (t),	2,890	v 1,638
Pottsville borough,	15,710	14,117
First ward,	2,040	
Second ward,	1,334	
Third ward,	2,877	
Fourth ward,	3,202	
Fifth ward,	3,805	
Sixth ward,	1,447	
Seventh ward,	1,005	
Rahn township,	2,933	2,648
Reilly township,	1,266	1,715
Rush township,	1,395	1,264
Ryan township,	719	706
St. Clair borough,	4,638	3,680
Middle ward,	1,528	
North ward,	1,232	
South ward,	1,878	
Schuylkill township,	715	545
Schuylkill Haven borough,	3,654	3,088
East ward,	1,433	
North ward,	946	
South ward,	978	
West ward,	257	
Shenandoah borough,	20,321	15,944
First ward,	5,789	
Second ward,	1,431	
Third ward,	3,715	
Fourth ward,	4,534	
Fifth ward,	4,852	
South Manheim township,	735	876
Tahaqua borough,	7,267	6,054
East ward,	1,429	
Middle ward,	1,500	
North ward,	2,328	
South ward,	2,010	
Tower City borough (t),	2,167	2,053
Tremont borough,	1,947	2,064
East ward,	1,110	
West ward,	837	
Tremont township,	740	771
Union township,	1,642	1,310
Upper Mahantango township,	785	732
Walker township,	542	569
Washington township,	1,338	1,338
Wayne township,	1,450	1,533
West Brunswick township,	1,158	1,373
West Mahanoy township,	4,864	4,743
West Penn township,	2,292	2,256
Yorkville borough,	1,125	916
SNYDER COUNTY,	17,304	17,651
Adams township,	707	636
Beaver township,	832	853
Centre township,	1,030	1,060

(t) Tower City village, formerly in Porter township, incorporated as a borough since 1890.

(v) Exclusive of population of Tower City village.

TABLE II—Population of Pennsylvania by Minor Civil Divisions: 1890 and 1900—Continued.

Minor Civil Divisions.	1900.	1890.
SNYDER COUNTY—Continued.		
Chapman township,	1,067	1,219
Franklin township,	1,286	1,144
Jackson township,	719	730
Middleburg borough,	513	420
Middlecreek township,	734	750
Monroe township,	1,215	1,279
Penn township,	1,263	1,261
Perry township,	1,150	1,287
Sellinsgrove borough,	1,336	1,315
Spring township,	1,123	1,206
Union township,	1,169	1,233
Washington township,	1,412	1,500
West Beaver township,	1,038	999
West Perry township,	700	752
SOMERSET COUNTY,	49,461	37,317
Addison township (v),	1,296	1,400
Allegheny township (w),	970	1,463
Benson borough (x),	249	.....
Berlin borough,	1,030	912
Black township,	843	738
Brothers Valley township,	1,931	1,704
Casselman borough (y),	150	.....
Conemaugh township,	1,585	1,529
Confluence borough,	871	444
Etlick township,	2,932	1,962
Fairhope township (z),	565	.....
Garrett borough (a),	488	.....
Greenville township,	849	619
Hooversville borough (b),	465	.....
Jefferson township,	862	866
Jenner township,	1,637	1,699
Jennertown borough,	96	95
Larimer township,	784	735
Lincoln township (c),	884	.....
Lower Turkeyfoot township,	870	933
Meyersdale borough,	3,024	1,847
Middlecreek township,	702	660
Millford township,	835	859
New Baltimore borough,	201	185
New Centreville borough,	105	104
Northampton township (w),	765	784
Ogle township,	625	151
Paint township (x),	6,835	1,451
Quemahoning township (b),	1,376	1,453
Rockwood borough,	685	553
Salisbury borough,	980	689
Shade township,	1,239	1,299
Somerfield borough (d),	178	.....
Somerset borough,	1,834	1,713
Somerset township (e),	3,324	3,462

(v) Part taken to form Somerfield borough since 1890.

(w) Part taken to form part of Fairhope township since 1890.

(x) Benson borough organized from part of Paint township since 1890.

(y) Organized from part of Upper Turkeyfoot township since 1890.

(z) Organized from parts of Allegheny, Northampton, and Southampton townships since 1890.

(a) Organized from part of Summit township since 1890.

(b) Hooversville borough organized from part of Quemahoning township since 1900.

(c) Organized from part of Somerset township since 1890.

(d) Organized from part of Addison township since 1890.

(e) Part taken to form Lincoln township since 1890.

TABLE II—Population of Pennsylvania by Minor Civil Divisions: 1890 and 1900—Continued.

Minor Civil Divisions.	1900.	1890.
SOMERSET COUNTY—Continued.		
Southampton township (f),	484	749
Stonycreek township,	1,834	1,790
Stoystown borough,	806	391
Summit township (g),	2,865	2,386
Upper Turkeyfoot township (h),	1,256	1,224
Ursina borough,	423	405
Wellersburg borough,	158	183
SULLIVAN COUNTY,	12,124	11,620
Cherry township,	2,708	2,367
Colley township,	1,926	1,662
Davidson township,	1,714	1,652
Dushore borough,	884	783
Eaglesmere borough (i),	312	.....
Elkland township,	976	1,068
Forks township,	313	780
Forksville borough,	152	191
Fox township,	538	693
Hillsgrove township,	686	805
Laporte borough,	443	375
Laporte township,	465	443
Shrewsbury township (i),	524	811
SUSQUEHANNA COUNTY,	40,043	40,083
Apolacon township,	396	513
Ararat township,	650	648
Auburn township,	1,669	1,805
Bridgewater township,	1,805	1,220
Brooklyn township,	964	1,000
Choconut township,	306	276
Clifford township,	1,184	1,125
Dimock township,	847	919
Dundaff township,	169	157
Forest City borough,	4,279	2,319
First ward,	1,961	.....
Second ward,	2,318	.....
Forest Lake township,	787	907
Franklin township,	622	654
Friendsville borough,	110	130
Gibson township,	962	1,080
Great Bend borough,	836	1,002
Great bend township,	1,000	1,135
Hallstead borough,	1,404	1,167
Harford township,	1,488	1,514
Harmony township,	1,008	1,379
Herrick township,	620	721
Hopbottom borough,	226	299
Jackson township,	849	945
Jessup township,	596	641
Lanesboro borough,	821	876
Lathrop township,	735	776
Lenox township,	1,204	1,492
Liberty township,	785	699
Little Meadows borough,	213	223
Middletown township,	665	724

(f) Part taken to form part of Fairhope township since 1890.

(g) Part taken to form Garrett borough since 1890.

(h) Part taken to form Casselman borough since 1890.

(i) Eaglesmere borough organized from part of Shrewsbury township since 1890.

TABLE II—Population of Pennsylvania by Minor Civil Divisions: 1890 and 1900—Continued.

Minor Civil Divisions.	1900.	1890.
SUSQUEHANNA COUNTY—Continued.		
Montrose borough,	1,827	1,735
First ward, 635		
Second ward, 510		
Third ward, 683		
New Milford borough,	715	768
New Milford township,	1,206	1,244
Oakland borough,	1,008	955
Oakland township,	542	590
Rush township,	1,106	1,164
Silver Lake township,	673	866
Springville township,	1,068	1,177
Susquehanna borough,	3,812	3,872
First ward, 2,012		
Second ward, 1,800		
Thomson borough,	309	302
Thomson township,	480	567
Uniondale borough,	351	360
TIOGA COUNTY,		
	49,086	52,313
Bloss township,	3,231	2,550
Blossburg borough,	2,423	2,568
Brookfield township,	863	1,021
Charleston township,	1,781	1,839
Chatham township,	1,046	1,208
Clymer township,	1,119	1,312
Covington borough,	450	496
Covington township,	1,067	1,122
Deerfield township,	964	893
Delmar township,	2,919	3,081
Duncan township,	1,467	2,449
Elk township,	630	639
Elkland borough (k),	1,109	1,006
Farmington township,	890	907
Gaines township,	1,306	1,187
Hamilton township,	2,209	2,376
Jackson township,	1,591	1,704
Knoxville borough,	862	679
Lawrence township,	1,000	1,017
Lawrenceville borough,	486	441
Liberty borough (l),	263	
Liberty township (l),	1,264	1,755
Mansfield borough,	1,847	1,762
Middlebury township,	1,549	1,658
Morris township,	1,811	1,849
Nelson borough,	542	540
Nelson township (k),	66	
Osceola borough,	693	838
Richmond township,	1,496	1,640
Roseville borough,	215	211
Rutland township,	838	880
Shippen township,	706	732
Sullivan township,	1,290	m 1,405
Tioga borough,	524	557
Tioga township,	1,251	1,424
Union township,	1,536	1,876
Ward township,	404	n 1,267

(k) Nelson township organized from part of Elkland borough since 1890.

(l) Liberty borough organized from part of Liberty township since 1890.

(m) Includes population of what was in 1890 Mainburg borough, the charter of said borough having been revoked.

(n) Includes population of what was, in 1890, Fallbrook borough, the charter of said borough having been revoked.

TABLE II—Population of Pennsylvania by Minor Civil Divisions: 1890 and 1900—Continued.

Minor Civil Divisions.	1900.	1890.
TIOGA COUNTY—Continued.		
Wellsboro borough,	2,954	2,961
First ward,	1,614	
Second ward,	1,340	
Westfield borough,	1,180	1,128
Westfield township,	1,115	1,261
UNION COUNTY,		
	17,592	17,820
Buffalo township,	1,718	1,694
East Buffalo township,	1,144	1,107
Gregg township,	896	964
Hartleton borough,	237	261
Hartley township,	1,647	1,712
Kelly township,	1,080	1,108
Lewis township,	896	1,017
Lewisburg borough,	3,457	3,248
North ward,	1,346	
South ward,	1,316	
West ward,	795	
Limestone township,	864	844
Mifflinburg borough,	1,436	1,417
East ward,	735	
West ward,	701	
New Berlin borough,	616	617
Union township,	656	750
West Buffalo township,	1,092	1,174
White Deer township,	1,853	1,907
VENANGO COUNTY,		
	49,648	o 46,640
Allegheny township,	405	536
Canal township,	883	959
Cherrytree township,	1,225	1,246
Clinton township,	916	835
Clintonville borough,	262	253
Cooperstown borough,	243	280
Cornplanter township (p),	1,200	2,457
Cranberry township (q),	3,321	3,275
Emlenton borough,	1,190	1,126
Franklin city,	7,317	6,221
First ward,	3,036	
Second ward,	2,822	
Third ward,	1,459	
Frenchcreek township,	943	(o)
Irwin township,	1,262	1,396
Jackson township,	854	843
Mineral township,	574	602
Oakland township,*	1,029	1,063
Oil City,	13,264	10,932
First ward,	2,039	
Second ward,	1,003	
Third ward,	1,196	
Fourth ward,	1,980	
Fifth ward,	1,371	
Sixth ward,	1,093	
Seventh ward,	1,458	
Eighth ward,	2,229	
Ninth ward,	895	

(o) Frenchcreek township and Polk borough (population 1,187) not separately returned in 1890.

(p) Part taken to form Rouseville borough since 1890.

(q) Part taken to form West End borough since 1890.

TABLE II—Population of Pennsylvania by Minor Civil Divisions: 1890 and 1900—Continued.

Minor Civil Divisions.	1900.	1890.
VENANGO COUNTY—Continued.		
Oilcreek township,	623	852
Pine Grove township,	1,255	1,234
Pleasantville borough,	671	928
Plum township,	1,017	1,042
Polk borough,	1,037	(r)
President township,	289	366
Richland township,	1,134	1,229
Rockland township,	1,745	1,957
Rouseville borough (s),	516	.....
Sandycreek township,	847	779
Scrubgrass township,	1,047	1,072
Silverly borough,	783	833
Sugarcreek township,	2,835	2,349
Sunville borough,	92	106
Utica borough,	268	321
Victory township,	272	351
West End borough (t),	329	.....
WARREN COUNTY,	38,946	37,585
Bear Lake borough,	275	313
Brokenstraw township,	1,209	1,224
Cherry Grove township,	440	383
Clarendon borough,	1,032	1,297
Columbus borough,	334	292
Columbus township,	905	1,062
Conewango township,	2,719	2,267
Corydon township,	646	527
Deerfield township,	711	681
Eldred township (u),	964	1,720
Elk township,	814	880
Farmington township,	982	983
Freehold township,	1,187	1,330
Glade township (v),	1,712	2,885
Grand Valley borough (u),	388	.....
Kinzua township,	1,236	941
Limestone township,	362	447
Mead township,	1,480	1,909
Pine Grove township,	1,424	1,694
Pittsfield township,	1,481	1,851
Pleasant township,	749	540
Sheffield township,	2,580	2,202
Southwest township,	959	1,195
Spring Creek township,	1,351	1,463
Sugar Grove borough (w),	511	.....
Sugar Grove township (w),	1,259	1,855
Tidioute borough,	1,237	1,328
Triumph township,	737	941
Warren borough (v),	8,043	4,332
First ward,	1,253	.....
Second ward,	1,014	.....
Third ward,	1,110	.....
Fourth ward,	1,552	.....
Fifth ward,	1,493	.....
Sixth ward,	1,621	.....

(r) Frenchcreek township and Polk borough not separately returned in 1890.

(s) Organized from part of Cornplanter township since 1890.

(t) Organized from part of Cranberry township since 1890.

(u) Grand Valley borough organized from part of Eldred township township since 1890.

(v) Part of Glade township annexed to Warren borough since 1890.

(w) Sugar Grove borough organized from part of Sugar Grove township since 1890.

TABLE II—Population of Pennsylvania by Minor Civil Divisions: 1890 and 1900—Continued.

Minor Civil Divisions.	1900.	1890.
WARREN COUNTY—Continued.		
Watson township,	322	376
Youngsville borough,	836	667
WASHINGTON COUNTY,	92,181	x 71,155
Allen township (y),	1,677	2,544
Amwell township,	1,848	1,903
Beallsville borough,	388	360
Bentleyville borough,	613	229
Blaine township (z),	637	.....
Buffalo township (z),	1,046	2,331
Burgettstown borough,	961	929
California borough,	2,009	1,024
Canonsburg borough,	2,714	2,113
East ward,	1,297	.....
West ward,	1,417	.....
Canton township (a),	2,177	1,830
Carroll township,	2,626	1,919
Cecil township,	3,771	2,285
Centreville borough (b),	746	.....
Charleroi borough (c),	5,930	.....
Chartiers township,	2,141	1,941
Claysville borough,	856	1,041
Coal Centre borough,	742	569
Cross Creek township,	856	966
Deemston borough (b),	428	.....
Donegal township,	1,424	1,568
East Bethlehem township (b),	790	1,757
East Finley township,	1,185	1,351
East Pike Run township,	2,071	1,162
East Washington borough (d),	1,051	.....
Elco borough (y),	850	850
Fallowfield township (c),	801	1,084
Finleyville borough (e),	447	.....
Hanover township,	1,763	1,767
Hopewell township,	662	783
Independence township,	772	899
Jefferson township,	776	825
Long Branch borough (y),	273	.....
McDonald borough,	2,475	1,688
Monongahela city,	5,173	4,096
First ward,	1,565	.....
Second ward,	1,654	.....
Third ward,	1,954	.....
Morris township,	1,000	1,076
Mt. Pleasant township,	1,551	1,487
North Charleroi borough (c),	425	.....
North Franklin township (f),	880	.....

(x) Includes population (1,654) of Franklin township, taken to form North and South Franklin townships.

(y) Elco, Long Branch, Roscoe, Speers, Stockdale, and Twilight boroughs organized from parts of Allen township since 1890.

(z) Blaine township organized from part of Buffalo township since 1890.

(a) West Washington borough organized from part of Canton township since 1890.

(b) Centreville and Deemston boroughs organized from parts of East Bethlehem township since 1890.

(c) Charleroi and North Charleroi boroughs organized from parts of Fallowfield township since 1890.

(d) East, North and South Washington boroughs organized from parts of South Strabane township since 1890.

(e) Finleyville borough organized from part of Union township since 1890.

(f) North and South Franklin townships organized from Franklin township since 1890.

TABLE II—Population of Pennsylvania by Minor Civil Divisions: 1890 and 1900—Continued.

Minor Civil Divisions.	1900.	1890.
WASHINGTON COUNTY—Continued.		
North Strabane township (g),	1,278	1,492
North Washington borough (d),	1,473	.....
Nottingham township,	1,179	1,087
Peters township,	1,596	1,225
Robinson township,	2,087	1,820
Roscoe borough (y),	1,354	.....
Smith township,	1,484	1,592
Somerset township,	1,130	1,273
South Canonsburg borough (g),	610	.....
South Franklin township (f),	693	.....
South Strabane township (d),	1,333	3,079
South Washington borough (d),	1,280	.....
Speers borough (y),	369	.....
Stockdale borough (y),	731	.....
Twilight borough (y),	136	.....
Union township (e),	3,109	3,621
Washington borough,	7,670	7,063
First ward,	1,654	.....
Second ward,	2,571	.....
Third ward,	1,905	.....
Fourth ward,	1,540	.....
West Alexander borough,	463	444
West Bethlehem township,	1,794	1,890
West Brownsville borough,	742	735
West Finley township,	1,352	1,525
West Middletown borough,	241	235
West Pike Run township,	860	898
West Washington borough (a),	2,693	.....
WAYNE COUNTY,	30,171	31,010
Berlin township,	1,100	1,005
Bethany borough,	130	134
Buckingham township,	1,062	1,067
Canaan township,	485	496
Cherry Ridge township,	677	673
Clinton township,	954	863
Damascus township,	2,408	2,442
Dreher township,	622	712
Dyberry township,	720	664
Hawley borough,	1,925	1,963
Honesdale borough,	2,884	2,816
Lake township,	1,286	1,189
Lebanon township,	548	541
Lehigh township,	401	355
Manchester township,	1,190	1,262
Mt. Pleasant township,	1,488	1,640
Oregon township,	410	452
Palmyra township,	757	929
Paupack township,	522	568
Preston township,	1,464	1,317
Prompton borough,	258	269
Salem township,	1,281	1,416

(g) South Canonsburg borough organized from part of North Strabane township since 1890.

(d) East, North and South Washington boroughs organized from parts of South Strabane township since 1890.

(y) Elco, Long Branch, Roscoe, Speers, Stockdale, and Twilight boroughs organized from parts of Allen township since 1890.

(f) North and South Franklin townships organized from Franklin township since 1890.

(e) Finleyville borough organized from part of Union township since 1890.

(a) West Washington borough organized from part of Canoton township since 1890.

TABLE II—Population of Pennsylvania by Minor Civil Divisions: 1890 and 1900—Continued.

Minor Civil Divisions.	1900.	1890.
WAYNE COUNTY—Continued.		
Scott township	1,101	1,147
South Canaan township	1,039	1,067
Starruca borough	404	431
Sterling township	672	710
Texas township	3,951	4,409
Waymart borough	432	435
WESTMORELAND COUNTY.		
	160,175	h 112,819
Adamsburg borough	184	223
Allegheny township (l)	3,175	2,316
Arnold borough (k)	1,426	
Arona borough (l)	382	
Avonmore borough (m)	630	
Bell township (n)	790	1,168
Bollivar borough	486	410
Cokeville borough	674	664
Cook township	1,175	1,226
Derry borough	2,347	1,963
North ward	637	
South ward	1,710	
Derry township	9,495	7,163
Donegal borough	157	163
Donegal township	1,341	1,319
East Greensburg borough (l)	1,050	
East Huntingdon township	10,587	8,109
Fairfield township	1,805	1,757
Franklin township	2,719	1,754
Greensburg borough (n)	6,506	4,202
First ward	1,627	
Second ward	960	
Third ward	901	
Fourth ward	1,580	
Fifth ward	1,432	
Hempfield township (l)	9,256	9,945
Hyde Park borough (o)	312	
Irwin borough	2,452	2,425
First ward	548	
Second ward	823	
Third ward	1,081	
Jeannette borough	5,865	3,236
First ward	2,340	
Second ward	1,439	
Third ward	2,086	
Latrobe borough	4,614	3,359
First ward	1,238	
Second ward	1,849	
Third ward	2,027	
Ligonier borough	1,259	782
Ligonier township	2,834	2,790
Livermore borough	175	211
Lower Burrell township (k)	1,019	839
Loyalhanna township	767	930

(h) Includes population (897) of Bunker Hill borough, annexed to Greensburg borough.

(l) Parts taken to form Hyde Park, Vandergrift and Vandergrift Heights boroughs since 1890.

(k) Arnold and New Kensington boroughs organized from parts of Lower Burrell township since 1890.

(l) Arona, East Greensburg, Southeast Greensburg, South Greensburg, and Southwest Greensburg boroughs organized from parts of Hempfield township since 1890.

(m) Avonmore borough organized from part of Bell township since 1890.

(n) Bunker Hill borough annexed since 1890.

(o) Organized from part of Allegheny township since 1890.

TABLE II—Population of Pennsylvania by Minor Civil Divisions: 1890 and 1900—Continued.

Minor Civil Divisions.	1900.	1890.
WESTMORELAND COUNTY—Continued.		
Ludwick borough,	901	891
Madison borough,	464	201
Manor borough (p),	684	578
Monessen borough (q),	2,197	.....
Mt. Pleasant borough,	4,745	3,652
First ward,	1,258	.....
Second ward,	1,718	.....
Third ward,	1,769	.....
Mt. Pleasant township,	10,228	7,758
New Alexandria borough,	364	338
New Florence borough,	800	683
New Kensington borough (k),	4,665	.....
New Salem borough (r),	381	311
North Belleverson borough,	810	455
North Huntingdon township (s),	7,438	7,125
North Irwin borough (s),	403	.....
Parnassus borough,	1,791	516
Penn borough,	763	931
Penn township (p),	5,321	t 3,223
Rostraver township (q),	6,231	3,895
St. Clair township,	1,122	836
Salem township,	2,587	2,395
Scottdale borough,	4,621	2,693
Sewickley township,	4,548	3,977
Southeast Greensburg borough (l),	620	.....
South Greensburg borough (l),	700	.....
South Huntingdon township,	4,758	3,674
Southwest Greensburg borough (l),	831	.....
Unity township,	9,402	5,494
Upper Burrell township,	555	606
Vandergrift borough (o),	2,076	.....
Vandergrift Heights borough (o),	1,910	.....
Washington township,	1,797	1,624
West Newton borough,	2,467	2,285
Youngstown borough,	771	456
WYOMING COUNTY,	17,152	15,891
Braintrim township,	934	827
Clinton township,	428	404
Eaton township,	790	865
Exeter township,	129	144
Factoryville borough,	659	577
Falls township,	1,090	1,013
Forkston township,	920	761
Lemon township,	577	604
Mehoopany township,	794	831
Meshoppen borough,	609	597
Meshoppen township,	584	596
Monroe township (u),	993	1,345
Nicholson borough,	893	734
Nicholson township,	318	905
North Branch township,	313	365

(p) Manor village, formerly in Penn township, incorporated as a borough since 1890.

(q) Monessen borough organized from part of Rostraver township since 1890.

(k) Arnold and New Kensington boroughs organized from parts of Lower Burrell township since 1890.

(r) Given as Salem in 1890.

(s) North Irwin borough organized from part of North Huntingdon township since 1890.

(t) Exclusive of population of Manor village.

(l) Arona, East Greensburg, Southeast Greensburg, South Greensburg, and Southwest Greensburg boroughs organized from parts of Hempfield township since 1890.

(o) Organized from part of Allegheny township since 1890.

(u) Noxen township organized from part of Monroe township since 1890.

TABLE II—Population of Pennsylvania by Minor Civil Divisions: 1890 and 1900—Continued.

Minor Civil Divisions.	1900.	1890.
WYOMING COUNTY—Continued.		
Northmoreland township,	855	863
Noxen township (u),	1,197	.....
Overfield township,	442	391
Tunkhannock borough,	1,306	1,253
Tunkhannock township,	1,450	1,336
Washington township,	711	739
Windham township,	681	771
YORK COUNTY,	116,412	99,489
Carroll township,	882	993
Chanceford township (v),	2,798	2,066
Codorus township,	2,251	2,322
Conewago township,	1,506	1,555
Cross Roads borough (w),	167	.....
Dallastown borough,	1,181	779
Delta borough,	684	565
Dillsburg borough,	732	587
Dover borough,	438	465
Dover township,	2,513	2,349
East Hopewell township (w),	1,074	1,234
East Manchester township,	1,359	1,412
East Prospect borough,	292	261
Fairview township,	2,078	2,042
Fawn township,	1,554	1,647
Fawn Grove borough,	202	199
Felton borough (x),	226	.....
Franklin township,	895	962
Franklintown borough,	260	232
Glen Rock borough,	1,117	687
Goldsboro borough,	385	345
Hanover borough,	5,302	3,746
First ward,	1,422	.....
Second ward,	2,408	.....
Third ward,	818	.....
Fourth ward,	654	.....
Heidelberg township,	1,013	954
Hellam township,	2,057	2,164
Hopewell township,	1,876	1,540
Jackson township,	1,596	1,608
Jefferson borough,	374	374
Lewisberry borough,	228	170
Loganville borough,	243	296
Lower Chanceford township,	2,845	2,512
Lower Windsor township,	2,649	2,764
Manchester borough,	507	513
Manchester township (y),	1,556	1,783
Manheim township,	1,226	1,258
Monaghan township,	847	923
Newberry township (z),	2,101	2,238
New Freedom borough,	560	364
New Salem borough,	241	231
North Codorus township (a),	2,637	2,639
North Hopewell township (i),	1,122	1,199

(u) Noxen township organized from part of Monroe township since 1890.

(v) Part taken to form part of Felton borough since 1890.

(w) Cross roads borough organized from part of East Hopewell township since 1890.

(x) Organized from parts of Chanceford, North Hopewell and Windsor townships since 1890.

(y) North York borough organized from part of Manchester township since 1890.

(z) Part taken to form York Haven borough since 1890.

(a) Seven Valley borough organized from parts of North Codorus and Springfield townships since 1890.

(i) Part taken to form part of Felton borough since 1890.

TABLE II—Population of Pennsylvania by Minor Civil Divisions: 1890 and 1900
—Continued.

Minor Civil Divisions.	1900.	1890.
YORK COUNTY—Continued.		
North York borough (y),	1,185	.....
Paradise township,	1,214	1,289
Peach Bottom township,	1,888	2,198
Penn township,	1,876	1,501
Railroad borough,	213	201
Red Lion borough,	1,337	524
Seven Valley borough (a),	423	.....
Shrewsbury borough,	554	562
Shrewsbury township,	1,953	2,041
Springetsbury township (b),	1,783	.....
Springfield township (a),	1,641	1,912
Spring Garden township (c),	879	5,209
Spring Grove borough,	1,005	576
Stewartstown borough,	573	441
Warrington township (d),	1,660	1,830
Washington township,	1,388	1,464
Wellsville borough (e),	296	.....
West Manchester township (f),	1,520	1,743
West Manheim township,	1,418	1,269
Windsor township (g),	2,516	2,372
Winterstown borough,	217	209
Wrightsville borough,	2,266	1,912
Yoe borough (h),	525	.....
York city (i),	33,708	20,793
First ward,	2,388	.....
Second ward,	1,587	.....
Third ward,	998	.....
Fourth ward,	1,803	.....
Fifth ward,	1,615	.....
Sixth ward,	2,777	.....
Seventh ward,	2,735	.....
Eighth ward,	2,317	.....
Ninth ward,	5,461	.....
Tenth ward,	2,517	.....
Eleventh ward,	3,869	.....
Twelfth ward,	4,594	.....
Thirteenth ward,	1,047	.....
York township (h),	2,793	2,489
York Haven borough (k),	524	.....

(y) North York borough organized from part of Manchester township since 1890.

(a) Seven Valley borough organized from parts of North Codorus and Springfield townships since 1890.

(b) Organized from part of Spring Garden township since 1890.

(c) Part taken to form Springetsbury township and part annexed to York city since 1890.

(d) Part taken to form Wellsville borough since 1890.

(e) Organized from part of Warrington township since 1890.

(f) Part annexed to York city since 1890.

(g) Part taken to form part of Felton borough since 1890.

(h) Yoe borough organized from part of York township since 1890.

(i) Formerly York borough; incorporated as a city since 1890; parts of Spring Garden and West Manchester townships annexed since 1890.

(k) Organized from part of Newberry township since 1890.

TABLE III—Population of Pennsylvania by Counties.

County.	Cities and Boroughs.		Townships.		Total.	
	1900.	1890.	1900.	1890.	1900.	1890.
Adams,	9,261	7,508	25,235	25,983	34,496	33,486
Allegheny,	646,752	422,170	128,306	129,789	775,058	551,959
Armstrong,	17,061	13,063	35,470	23,684	52,551	46,747
Beaver,	33,489	26,401	22,943	23,676	56,432	50,077
Bedford,	8,634	7,699	30,834	30,945	39,468	38,644
Berks,	30,243	69,249	69,372	68,078	139,615	137,327
Blair,	56,612	44,638	28,467	26,828	85,099	70,866
Bradford,	20,324	13,616	39,079	45,617	59,408	59,233
Bucks,	24,071	18,124	47,119	52,481	71,190	70,615
Butler,	19,163	14,510	37,799	40,829	56,962	55,339
Cambria,	62,961	33,557	41,876	32,818	104,837	66,375
Cameron,	2,972	2,775	4,076	4,463	7,048	7,238
Carbon,	25,373	20,674	19,137	17,950	44,510	38,624
Centre,	11,496	9,948	31,398	33,321	42,894	43,269
Chester,	38,215	30,256	57,480	59,122	95,695	89,377
Clarion,	8,197	8,117	26,086	28,685	34,283	36,802
Clearfield,	28,018	19,420	52,596	50,145	80,614	69,565
Clinton,	15,272	13,884	18,925	14,801	29,197	28,685
Columbia,	16,001	11,906	23,895	24,936	39,596	36,832
Crawford,	26,876	25,260	26,767	40,064	63,643	65,324
Cumberland,	21,917	18,004	28,427	29,267	50,344	47,271
Dauphin,	82,199	64,682	32,244	32,296	114,443	96,977
Delaware,	60,044	31,994	34,718	42,689	94,763	74,685
Elk,	11,704	4,928	21,199	17,311	32,903	23,239
Erie,	68,274	54,658	30,199	31,416	98,473	86,074
Fayette,	28,794	21,269	51,618	58,740	110,412	80,006
Forest,	815	677	10,224	7,806	11,039	8,482
Franklin,	16,924	14,428	37,978	37,006	54,902	51,433
Fulton,	579	594	9,348	9,543	9,924	10,137
Greene,	4,055	3,300	24,226	25,635	28,251	25,935
Huntingdon,	12,425	12,276	22,225	23,475	34,650	35,751
Indiana,	11,863	8,127	30,693	34,048	42,566	42,175
Jefferson,	16,910	11,973	42,208	32,032	59,113	44,006
Juniata,	2,583	2,513	13,465	14,142	16,064	16,655
Lackawanna,	173,205	115,601	20,626	26,487	193,831	142,086
Lancaster,	70,880	55,391	88,361	93,704	159,241	149,095
Lawrence,	32,704	13,060	24,338	24,467	57,042	37,517
Lebanon,	18,199	15,307	35,628	32,824	53,827	48,137
Lehigh,	52,128	37,268	41,765	39,363	93,393	76,631
Luzerne,	166,888	118,879	90,233	82,324	257,121	201,203
Lycoming,	42,870	38,174	32,793	32,405	75,683	70,579
McKean,	26,398	16,888	24,945	29,975	51,343	46,863
Mercer,	25,604	22,435	31,783	33,309	57,387	55,744
Mifflin,	5,355	4,206	17,805	15,791	23,160	19,996
Monroe,	6,567	4,705	14,594	15,406	21,161	20,111
Montgomery,	64,855	53,141	74,140	70,149	138,995	123,290
Montour,	8,264	8,169	7,272	7,476	15,526	15,645
Northampton,	61,505	42,305	38,182	41,915	99,687	84,220
Northumberland,	53,304	40,144	37,607	34,554	90,911	74,688
Perry,	7,635	6,545	18,628	19,731	26,283	26,276
Philadelphia,	1,293,697	1,046,964			1,293,697	1,046,964
Pike,	884	793	7,882	8,619	8,766	9,412
Potter,	8,551	3,668	22,070	19,110	30,621	22,778
Schuylkill,	107,634	91,629	65,293	62,534	172,927	154,163
Snyder,	1,839	1,735	15,465	15,916	17,304	17,661
Somerset,	11,243	7,421	38,218	29,896	49,461	37,317
Sullivan,	1,790	1,349	10,344	10,271	12,134	11,620
Susquehanna,	16,166	14,169	23,877	25,924	40,043	40,093
Tioga,	13,548	12,187	35,538	39,126	49,066	52,313
Union,	5,746	5,543	11,846	12,277	17,592	17,820
Venango,	25,972	21,010	23,676	25,620	49,648	46,640
Warren,	12,716	8,229	26,220	29,356	38,946	37,586

TABLE III—Population of Pennsylvania by Counties—Continued.

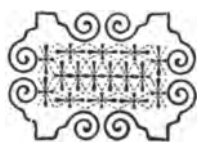
County.	Cities and Boroughs.		Townships.		Total.	
	1900.	1890.	1900.	1890.	1900.	1890.
Washington,	43,792	20,536	48,389	50,619	92,181	71,155
Wayne,	6,013	6,056	24,158	24,954	30,171	31,010
Westmoreland,	61,125	31,936	99,060	80,883	160,175	112,819
Wyoming,	3,466	3,161	13,686	12,730	17,152	15,891
York,	56,350	35,032	60,063	64,467	116,413	99,489
Total,	3,986,983	2,966,214	2,315,132	2,291,800	6,302,115	5,258,014

TABLE IV—Population of Pennsylvania. Indicating Gains in Cities and Boroughs and in Townships from 1890 to 1900.

County.	Cities and Boroughs.		Townships.	
	Gain.	Loss.	Gain.	Loss.
Adams,	1,758			748
Allegheny,	224,582			1,483
Armstrong,	4,028		1,776	
Beaver,	7,068			733
Bedford,	935			111
Berks,	20,994		1,294	
Blair,	12,574		1,659	
Bradford,	6,708			6,538
Bucks,	5,987			5,362
Butler,	4,653			3,030
Cambria,	29,404		9,058	
Cameron,	197			387
Carbon,	4,699		1,187	
Centre,	1,548			1,923
Chester,	7,960			1,642
Clarion,	80			2,539
Clearfield,	8,598		2,451	
Clinton,	1,388			876
Columbia,	4,095			1,081
Crawford,	1,616			3,297
Cumberland,	3,913			840
Dauphin,	17,517			51
Delaware,	28,060			7,971
Elk,	6,778		3,888	
Erie,	13,616			1,217
Fayette,	7,528		22,878	
Forest,	138		2,419	
Franklin,	2,496		973	
Fulton,		18		195
Greene,	755			1,409
Huntingdon,	149			1,250
Indiana,	3,736			3,355
Jefferson,	4,937		10,171	
Juniata,	76			677
Lackawanna,	57,604			5,861
Lancaster,	15,489			5,343
Lawrence,	19,654			129
Lebanon,	2,892		2,804	
Lehigh,	14,860		2,402	
Luzerne,	48,009		7,909	
Lycoming,	4,696		388	
McKean,	9,510			5,030
Mercer,	3,169			1,526
Mifflin,	1,150		2,014	
Monroe,	1,862			812
Montgomery,	11,714		3,991	
Montour,	85			204
Northampton,	19,200			3,733
Northumberland,	13,160		3,053	
Perry,	1,090			1,103
Philadelphia,	246,733			
Pike,	91			737
Potter,	4,583		2,960	
Schuylkill,	16,005		2,759	
Snyder,	104			451
Somerset,	3,822		8,322	
Sullivan,	441		73	
Susquehanna,	1,997			2,047
Tioga,	361			3,588
Union,	203			431
Venango,	4,962			1,964

TABLE IV—Population of Pennsylvania—Continued.

County.	Cities and Boroughs.		Townships.	
	Gain.	Loss.	Gain.	Loss.
Warren,	4,487			3,126
Washington,	23,256			2,230
Wayne,		43		796
Westmoreland,	29,189		18,167	
Wyoming,	206		956	
York,	21,318			4,394
Total,	1,020,830	61	113,552	90,220



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